**FM 5-34**
**14 September 1987**

By Order of the Secretary of the Army:

CARL E. VUONO
*General, United States Army*
*Chief of Staff*

Official:

R. L. DILWORTH
*Brigadier General, United States Army*
*The Adjutant General*

DISTRIBUTION:

*Active Army, USAR, and ARNG:* To be distributed in accordance with DA Form 12-11A. Requirements for Engineer Field Data (Qty rqr block no. 26).

☆ GPO : 1991 0 - 281-486 (43664)

# CONTENTS


| | | Page |
|---|---|---|
| Chapter 1 | **COMBAT OPERATIONS** | 1-1 |
| | Combat Orders | 1-1 |
| | Combat Preparations | 1-1 |
| | Mounted/Dismounted Operations | 1-4 |
| | Fire Support Procedures and Characteristics | 1-10 |
| | Nuclear, Biological, Chemical | 1-15 |
| | Medical Procedures | 1-28 |
| | Communication | 1-37 |
| Chapter 2 | **MOBILITY** | 2-1 |
| | Threat Defense | 2-1 |
| | Countermine | 2-3 |
| | Obstacle Breaching | 2-13 |
| | Combat Roads and Trails | 2-18 |
| | Forward Aviation | 2-23 |
| Chapter 3 | **COUNTERMOBILITY** | 3-1 |
| | Threat Offense | 3-1 |
| | Obstacles | 3-3 |
| | Mine Warfare | 3-16 |
| | Expedient Mines | 3-49 |
| Chapter 4 | **SURVIVABILITY** | 4-1 |
| | Weapons Fighting Positions | 4-1 |
| | Vehicle Positions | 4-8 |
| | Trenches, Revetments, Bunkers, and Shelters | 4-13 |
| | Camouflage | 4-18 |
| Chapter 5 | **RECONNAISSANCE** | 5-1 |
| | Route Reconnaissance | 5-1 |
| | Road Reconnaissance | 5-3 |
| | Bridge Reconnaissance | 5-6 |
| | Tunnel Reconnaissance | 5-14 |
| | Water Crossing Reconnaissance | 5-15 |
| | Ford Reconnaissance | 5-16 |
| | Engineer Reconnaissance | 5-17 |
| | Overlay Symbols | 5-19 |
| Chapter 6 | **DEMOLITIONS** | 6-1 |
| | Safety | 6-1 |
| | Explosive Characteristics | 6-2 |
| Chapter 6 | **DEMOLITIONS - Continued** | |
| | Priming Explosives | 6-2 |
| | Firing Systems | 6-3 |
| | Charge Calculations | 6-3 |
| | Bridge Demolitions | 6-13 |
| | Expedient Demolitions | 6-21 |
| Chapter 7 | **BRIDGING** | 7-1 |
| | River Crossing | 7-1 |
| | M4T6 Fixed Span | 7-20 |
| | Medium Girder Bridge (MGB) | 7-30 |
| | Bailey Bridge Type M-2 | 7-49 |
| | Hasty Nonstandard Fixed Bridges | 7-68 |
| Chapter 8 | **ROADS AND AIRFIELDS** | 8-1 |
| | Soils | 8-1 |
| | Drainage | 8-4 |
| | Expedient Pavements | 8-10 |
| | Airfield Repair | 8-11 |
| Chapter 9 | **RIGGING AND VEHICLE RECOVERY** | 9-1 |
| | Ropes | 9-1 |
| | Chains and Hooks | 9-2 |
| | Spruce Timbers | 9-3 |
| | Knots, Lashings, and Fastenings | 9-3 |
| | Anchorages and Guy Lines | 9-9 |
| | Highline | 9-10 |
| | Expedient Vehicle Recovery | 9-11 |
| Chapter 10 | **MISCELLANEOUS FIELD DATA** | 10-1 |
| | Specific Weights and Gravities | 10-1 |
| | Construction Material | 10-3 |
| | Soil Conversion | 10-6 |
| | Trigonometric Functions and Geometric Figures | 10-7 |
| | Conversion Factors | 10-11 |
| | US Equipment and Weapons Characteristics | 10-19 |
| | Operational Symbols | 10-26 |
| **Glossary** | | Glossary-1 |
| **References** | | References-1 |
| **Index** | | Index-1 |

# Chapter 1
# Combat operations

## COMBAT ORDERS

Combat orders are written or oral communications used to transmit information pertaining to combat operations.

### Warning Order

A warning order gives advance notice of a contemplated action or order which is to follow. Although a warning order has no prescribed format, all known elements should be included. Figure 1-1 represents a suggested format.

**WARNING ORDER** - Stated to alert recipients
**ADDRESSEES** - To whom the order pertains
**SITUATION** - A short concise statement of the friendly and enemy situation
**TIME/NATURE OF OPERATION** - Type of mission
**EARLIEST TIME OF MOVE**
**TIME/PLACE FOR OPORD ISSUANCE**
**SPECIAL INSTRUCTIONS** - Details of early coordination to be made rehearsals and special equipment requirements
**ACKNOWLEDGE**

**Figure 1-1. Warning order - essential elements**

### Operation Order (OPORD)

The operation order sets forth the organization for combat (task organization), the situation, the mission, the commander's decision and plan of action, and the details of the execution needed to ensure coordinated action by a unit. The standard OPORD format is shown in Figure 1-2 (page 1-2).

### Fragmentary Order

A fragmentary order is used to change or modify the OPORD. It normally follows the OPORD format but only includes the items to be changed or modified.

## COMBAT PREPARATIONS

### Tactical Reed Marches

**Movement order**

Movement order or briefing should include as a minimum the following:

- Enemy and friendly situation.
- Destinat ion.
- Star critical release and rally points.
- Rate of march and catch up speed.
- Support (indirect, direct and medical and communications.
- Actions on contact.
- Order of march.
- Route alternate route.
- Distance between vehicles (day - 50 - meters, night - 25 - meters).
- Departure time.
- Location of commander.
- Lead vehicle (security reconnaissance).

**Rates of march**

See Table 1-1 (page 1-3)

**March security**

Each vehicle must be assigned a sector of fire (Figure 1-3, page 1-3). Vehicle crew maintains 360° observation and an air guard.

**Halts**

Security is first priority on any scheduled, unscheduled or disabled vehicle halt. Two halt formations are shown in Figure 1-4 (page 1-3).

**OPORD NO**

**REFERENCES**. List any maps or documents needed to understand the order or that were used in the preparation of the order

**TIME ZONE USED THROUGHOUT THE ORDER**

**TASK ORGANIZATION**

**1 SITUATION**

a Enemy forces

(1) Situation (enemy, weather, and terrain)

(2) Capabilities

(3) Probable course of action

b Friendly forces

(1) Mission of your parent unit

(2) Mission of unit providing you support

(3) Mission and/or route of adjacent units that may affect your operation

c Attachments and detachments

**2 MISSION**

Who, what, when, where (coordinates), and why

**3 EXECUTION**

a Concept of operation. The overall plan (scheme of maneuver) for the unit and plan for fire support (refer to annex)

b Commander's intent. How commander views the upcoming operations

c Subunit missions. For sections, teams, and individuals

d Coordinating instructions

(1) Time schedule

(2) Formations and order of movement

(3) Route (primary and alternate)

(4) Movement within friendly front lines

(5) Rally points and actions at rally points

(6) Actions on enemy contact, at danger areas, and at the objective

(7) Nuclear, biological, chemical (NBC) safety instructions and mission-oriented protection posture (MOPP) level

(8) Priority intelligence requirements (PIR)

(9) Fire support (if not already discussed)

(10) Rehearsal and inspections

(11) Debriefing (include essential elements of information (EEI), other intelligence requirements (OIR), time, and place)

(12) Annexes (other actions may be covered separately)

**4 SERVICE SUPPORT**

a Supply

(1) Rations

(2) Uniforms

(3) Arms and ammunitions

(4) Captured material

b Transportation

c Medical evacuation

d Personnel

e Prisoners of war

**5 COMMAND AND SIGNAL**

a Command

(1) Commander, leader location

(2) Chain of command

b Signal

(1) Frequencies and call signs

(2) Pyrotechnics and signals

(3) Challenges and passwords

(4) Code words

NOTES 1. The OPORD heading items may be omitted depending on the situation

2. Details under subparagraphs should be tailored to provide all relevant and essential information

3. Items covered by standing operating procedures (SOP) need not be covered in the OPORD

Figure 1-2. Format for an operation order

Table 1-1. Average rates of marches

| Unit | Average Rates of March KMPH (MPH) | | | | Days March Kilo-meters |
|---|---|---|---|---|---|
| | On Roads | | Cross-country | | |
| | Day | Night | Day | Night | |
| Foot troops | 4 (2 5) | 3 2 (2) | 2 4 (1 5) | 1 6 (1) | 20-32 (12-20) |
| Trucks. general | 40 (25) | 40 (lights) 16 (black-out) | 12 (7 5) | 8 (5) | 280 (174) |
| Tracked vehicles | 24 (15) | 24 (lights) 16 (black-out) | 16 (10) | 8 (5) | 240 (149) |
| Truck-drawn artillery | 40 (25) | 40 (lights) 16 (black-out) | 12 (7 5) | 8 (5) | 280 (174) |
| Tractor-drawn artillery | 32 (20) | 32 (lights) 16 (black-out) | 16 (10) | 8 (5) | 240 (149) |

**NOTES:** 1. This table is for general planning and comparison purposes. All rates given are variable in accordance with the movement conditions as determined by reconnaissance. The average rates include periodic rest halts.

2.. Miles per hour are listed in parentheses.

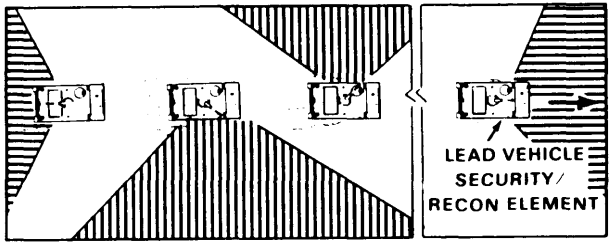



Figure 1-3. Sectors of fire

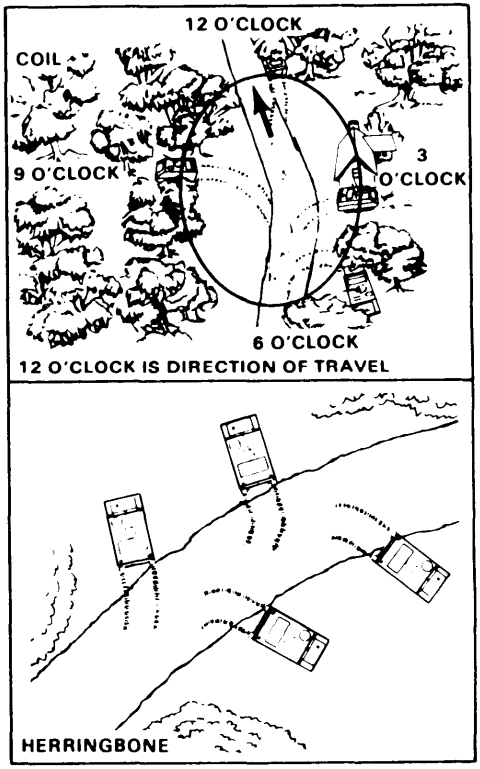



Figure 1-4. Halt formations

### Bivouac and Assembly Areas

Area must be organized to provide a continuous 360° perimeter security. When any element leaves the perimeter, either shrink the perimeter or redistribute the perimeter responsibilities. Crew served weapons are the basis for the unit defense. Individual weapons provide security for the crew - served weapons and must have overlapping sectors of fire.

Selection characteristics are:

- Concealment.
- Cover from direct and indirect fire.
- Defendable terrain.
- Drainage and a surface that will support vehicles.
- Exits and entrances. and adequate internal roads or trails.
- Space for dispersion of vehicles, personnel, and equipment.
- Suitable landing site nearby for supporting helicopters.

Quartering party responsibilities are:

- Reconnoiters the area.
- Checks the area for NBC hazards.
- Checks the area for obstacles and mines then marks or removes them.
- Marks platoon and squad sectors.
- Selects a command post location.
- Selects a company trains location.
- Provides guides for the incoming unit(s) to accomplish immediate occupation.

Recommended priority of work is:

- Post local security (LP/ OP).
- Position crew served weapons (combat engineer vehicle (CEV) antitank (AT) weapons and machine guns) and chemical alarms.
- Assign individual fighting positions.
- Clear fields of fire prepare range cards and camouflage vehicles.
- Prepare hasty fighting positions.
- Install change to land line communication.
- Emplace obstacles and mines.
- Construct primary lighting positions.
- Prepare alternate and supplementary fighting positions.
- Stockpile ammunition food and water.

Recommended actions at the bivouac and assembly area are:

- Reorganization.
- Weapons check.
- Maintenance.
- Distribution of supplies.
- Rest and personal hygiene.
- Consumption of rations.

## MOUNTED/DISMOUNTED OPERATIONS

### Troop Leading Procedures

The eight steps of troop leading are:

1. Receive the mission.
2. Issue a warning order.
3. Make a tentative plan that will accomplish the mission.
4. Start the necessary movement.
5. Reconnoiter.
6. Complete the plan.
7. Issue orders.
8. Supervise and refine the plan.

### Movement Techniques

See Figures 1-5 and 1-6 for traveling and bounding overwatches.

The dismounted squad moves with one fire team following the other. Both fire teams use the wedge formation for all movements (Figure 1-7). See Figure 1-8 for the movement formations.

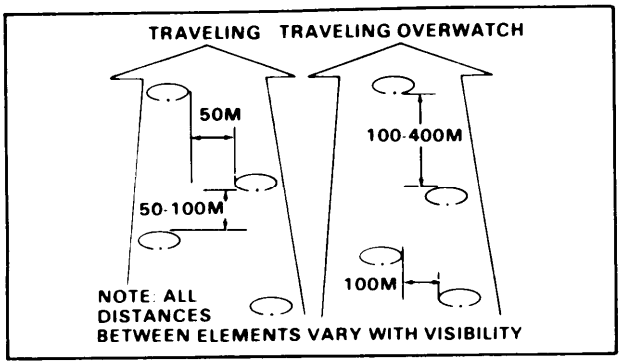



Figure 1-5. Traveling and traveling overwatch

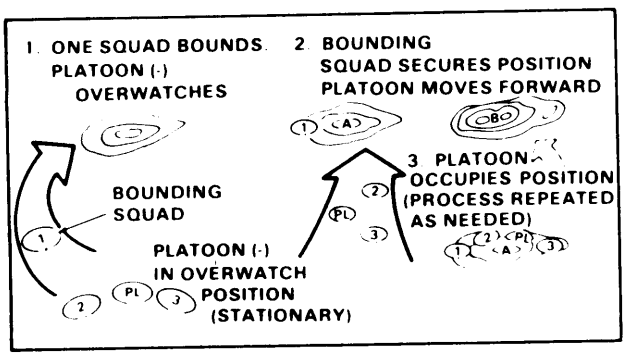



Figure 1-6. Bounding overwatch

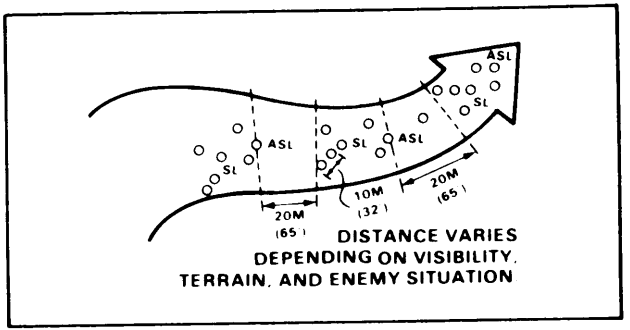



Figure 1-7. Traveling dismount elements

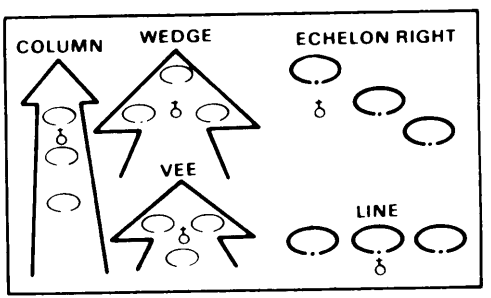



Figure 1-8. Movement formations

## Job Sites Security

Prior to moving to the job site, inform everyone of warning signals, code words, and pyrotechnics. Upon arrival at job site vicinity:

- Occupy job site overwatching position.
  - Dispatch reconnaissance/minesweeping/NBC team to secure job site.
  - After the area is secured, move into area and establish hasty perimeter.
  - Establish escape routes and identify avenues of approach, LP/OPs, and crew-served weapons positions.
  - Place LP/OP and NBC alarms.
- Position crew-served, AT, and automatic weapons, and prepare range cards.
  - Divide job site into defensive sectors and assign sectors of responsibility.
- Maintain communication with parent unit.

## Patrolling

The two types of patrol are reconnaissance (zone or area) and combat (ambush, security or raid). The four key principles of a successful patrol are detailed planning thorough reconnaissance positive control and all around security. The steps to follow in preparation for a patrol are:

1. Issue warning order.
2. Conduct required coordination (Figure 1 - 9).
3. Issue operation order.
4. Inspect and rehearse.

### Reconnaissance patrol

Figure 1 - 10 shows the techniques used by a reconnaissance patrol. The Information should be collected following the SALUTE (size, activity, location, unit, time, and equipment) report format. The gathered information must be shared with all patrol members.

**S3**

- Changes in the friendly situation.
- Route selection, loading zone (LZ) selection.
- Linkup procedure.
- Transportation.
- Resupply (in conjunction with S4).
- Signal plan — callsigns, frequencies, code words, pyrotechnics, and challenges and passwords.
- Departure and reentry of friendly lines (see below).
- Other patrols patrolling in area.
- Attachment of specialized troops (demolition team, scout dog team, forward observers (FO), interpreters).
- Rehearsal areas.
  - Terrain similar to objective site.
  - Security of the area.

**S3 (cont)**

- Use of blanks, pyrotechnics, live ammunition.
- Fortification available.
- Time the area is available.
- Transportation.

**FRIENDLY FORWARD UNIT**

Patrol leader gives:

- Identification (unit).
- Size of patrol.
- Time(s) of departure and return.
- Area of the patrol's operation (if it is within the forward unit's area of operation).

Forward unit gives:

- Information on terrain.
- Known or suspected enemy positions.
- Likely enemy ambush sites.
- Latest enemy activity.

**FRIENDLY FORWARD UNIT (cont)**

- Detailed information on friendly positions.
- Obstacle locations.
- Fire plan.
- Support the unit can furnish, such as fire support, litter teams, guides, communications, and reaction units.
- Signal plan to include the signals to be used upon reentry, and the procedure to be used by the patrol and guide during departure and reentry.
- Location(s) of detrucking point, initial rally point, departure point, and reentry point.

**ADJACENT PATROL**

- Identification.
- Mission.
- Route.
- Fire plan.
- Signal plan.

**ADJACENT PATROL (cont)**

- Planned times and points for departure and reentry.
- Any information that either patrol may have about the enemy.

**FIRE SUPPORT OFFICER (FSO)**

- Mission and objective.
- Routes to and from the objective (include alternate routes).
- Time of departure and expected time of return.
- Fire plan to include targets en route to and from the objective, and fire on and near the objective.
- Communications (primary and alternate means, emergency signals, and code words).

**S2**

- Changes in the enemy situation.
- Special equipment requirements.

**Figure 1-9. Patrol coordination checklist**

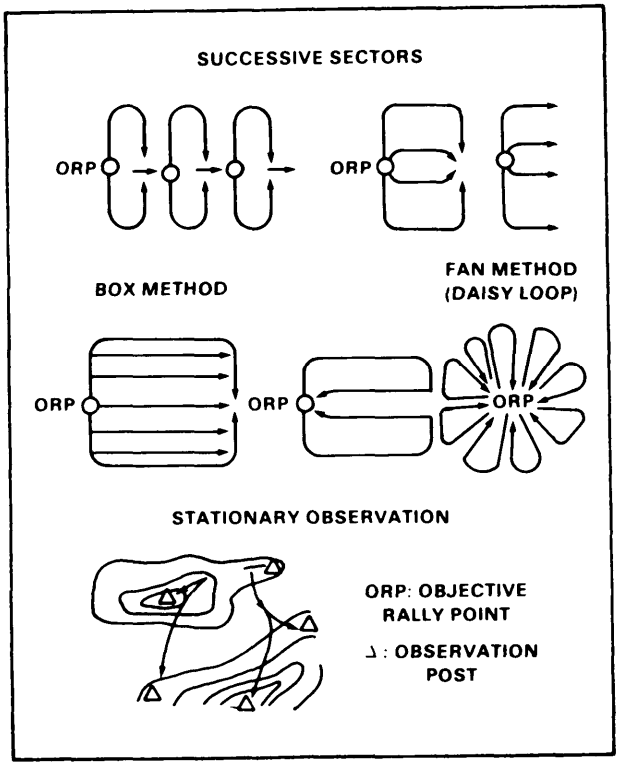



**Figure 1-10. Techniques for conducting reconnaissance**

**Combat patrol**

**Ambush and security.** See Figures 1-11 through 1-14 (pages 1-8 and 1-9). Key points for a successful ambush are:

- Surprise.
- Security.
- Restricted enemy movement in kill zone.
- Good fields of fires.
- Withdrawal routes for ambush force.
- Use of fire from unexpected direction.
- Cover and concealment.

**Raid.** Raid patrols destroy or capture personne, equipment, and/or installation. (Figure 1-15, page 1-9).

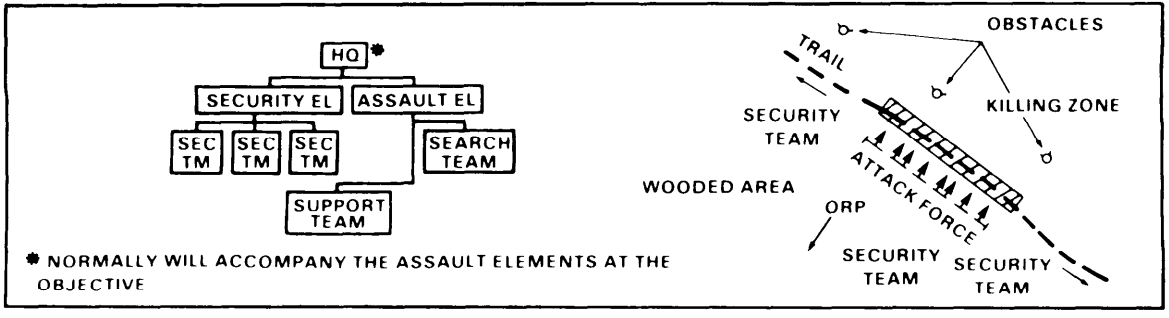



Figure 1-11. Typical organization and employment - point (linear) ambush

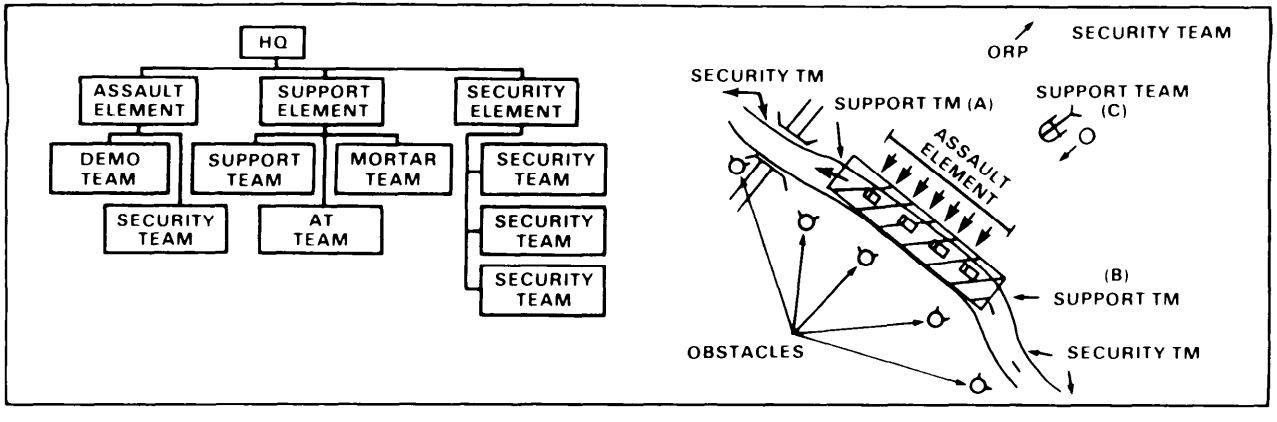



Figure 1-12 Typical organization and employment point (vehicular) ambush

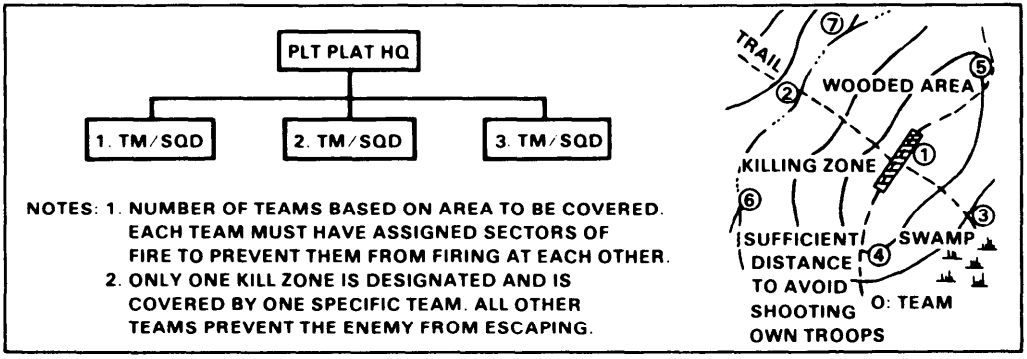



Figure 1-13. Typical organization for an area ambush

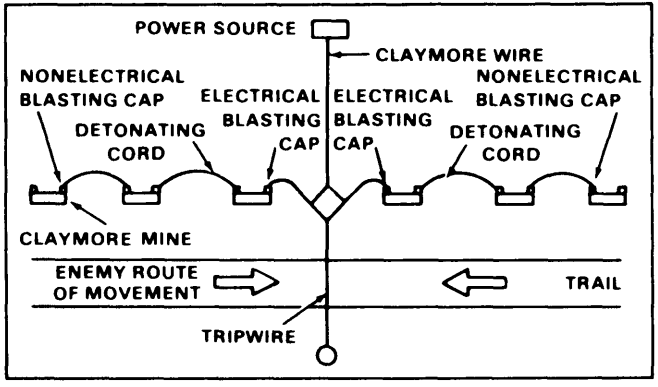



Figure 1-14. Multiclaymore mine mechanical ambush

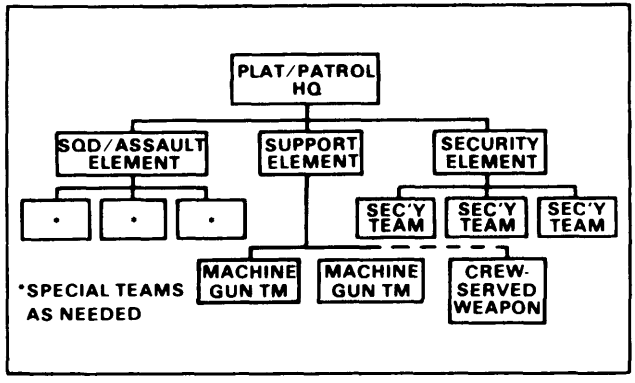



Figure 1-15. Typical organization for a raid patrol

## FIRE SUPPORT PROCEDURES AND CHARACTERISTICS

### Call for Fire Elements

**Identification**
Call signs

**Warning order**
Type mission adjust fire, fire for effect, immediate suppression.
Method of target location grid, polar, shift from known point.

**Target location**
Grid: six-digit grid
direction*
Polar: direction*
distance
vertical correction
(fire direction center must know observer location)

*Direction can be given in degrees, mils or cardinal directions.

Shift: right/left from known point
add/drop from known point
vertical correct from known point
(fire direction center must have known point)

**Target description**
Size, number, type. degree of protection, status

**Method of engagement (optional)**
Ammunition/fuze desired, sheaf corrections, high angle, danger close.

**Method of fire and control (optional)**
At my command, time on target, request splash.

**NOTE:** Direction must be given before any subsequent corrections when adjusting fires.

**Target location examples**

GRID COORDINATES

"F6A15, THIS IS F6A27 . . . . . Call signs of the fire direction center (FDC) and observer.
ADJUST FIRE, OVER" . . . . . Warning to alert the firing unit.
"GRID 135246, OVER". . . . . Normally, a six-digit grid is best.
"2 MACHINE GUNS FIRING . . . . . .Description of the target.
VT IN EFFECT, OVER" . . . . . Adjustment is conducted with fuze quick. Fuze variable time (VT) will be used in fire for effect.
"DIRECTION 1650, OVER." . . . . . .Must be sent before or with first correction.

POLAR COORDINATES

"F6A15, THIS IS F6A27 . . . . . .Call signs of the FDC and observer.
FIRE FOR EFFECT, POLAR, OVER" . . . . . Warning to alert the firing unit.
"DIRECTION 0250, . . . . . .Direction from the **observer** to the **target.**
DISTANCE 3500, OVER." . . . . . Distance from the **observer** to the **target.**
"25 INFANTRYMEN IN OPEN, . . . . . Description of the target.
ICM, AT MY COMMAND, OVER." . . . . Improved capabilities missile (ICM) rounds wil be used. The observer wil command **FIRE** at the appropriate time after the FDC informs the observer that the firing unit is **READY.**

SHIFT FROM A KNOWN POINT

"F6A15, THIS IS F6A27 . . . . . Call signs of the FDC and observer
FIRE FOR EFFECT, SHIFT
BG4301, OVER" . . . . . Warning to alert the firing unit.
"DIRECTION 5470, . . . . . Direction from the **observer** to the **target.**
LEFT 400, OVER " . . . . . The target is located 400 meters to the left of BG4301 and at the same range. (Lateral shift or range changes can be omitted when not needed.)
"25 INFANTRYMEN IN SHALLOW . . . . . Description of the target.
FOXHOLES, VT IN EFFECT OVER" . . . . . Airbursts are most effective against protected personnel without overhead cover.

**Call for fire example**

| OBSERVER | FIRE DIRECTION CENTER |
|---|---|
| "F6A15, THIS IS F6A27, ADJUST FIRE, OVER" . . . . . | "F6A27, THIS IS F6A15, ADJUST FIRE, OUT" |
| "GRID 563192, OVER " . . . . . | ."GRID 563192, OUT" |
| "25 INFANTRY IN OPEN, QUICK AND VT IN EFFECT, OVER " . . . . . | ."25 INFANTRY IN OPEN, QUICK AND VT IN EFFECT, AUTHENTICATE TANGO, FOXTROT, OVER |
| "'AUTHENTICATION IS ECHO, OUT" | |
| "DIRECTION 1930, OVER." . . | ."DIRECTION 1930, OUT." "BRAVO, 4 ROUNDS, OVER." |
| "BRAVO, 4 ROUND, OUT." . . . | ."SHOT, OVER." |
| "SHOT, OUT." | |
| "ADD 200, OVER . . . . . | "'ADD 200, OUT." "SHOT, OVER." |
| "SHOT, OUT." | |
| "DROP 100, OVER." . . . . . | "DROP 100 OUT." "SHOT, OVER." |
| "SHOT, OUT." | |
| "LEFT 30, DROP 50, FIRE FOR EFFECT, OVER." . . . . . | ."LEFT 30, DROP 50, FIRE FOR EFFECT, OUT." "SHOT, OVER." |
| "SHOT, OUT." . . . . . | "ROUNDS COMPLETE, OVER." |
| "ROUNDS COMPLETE, OUT. " | |
| "END OF MISSION, INFANTRY DISPERSED, ESTIMATE 15 CASUALTIES, OVER" . . . . . | ."END OF MISSION, INFANTRY DISPERSED, ESTIMATE 15 CASUALTIES. OUT. " |

## Adjustments

The adjustments that may be needed to obtain round on target are spotting, lateral, and range.

### Spotting

Is where round lands in relation to target, such as short or long and number of mils right or left of target. Example of spottings short 40 right or long 50 left.

### Lateral correction (right/left)

Adjust the lateral shift from impact to observer target (OT) line in meters. Corrections of 20 meters or less will be ignored until firing for effect.

$$W = Rm$$

W = Lateral shift correction in meters
m = mils between burst and target
R = OT factor = $\frac{\text{target range}}{1{,}000}$ (to nearest 1,000 meters)

NOTE: If target range is less than 1,000 meters, round to nearest 100 meters.

### Range correction (up/down)

Mechanical time fuze only. Initial range shift correction is used to bracket target. (Table 1-2).

### Range deviation

See Figure 1-16.

**Table 1-2. Target bracketing**

| DISTANCE TO TARGET | CHANGE |
|---|---|
| Less than 1,000 | +/- 100 meters |
| 1,000 to 1,999 | +/- 200 meters |
| 2,000 or greater | +/- 400 meters |

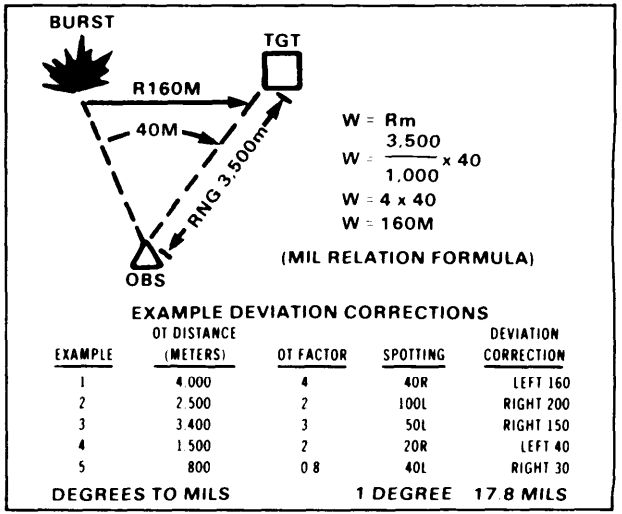



**Figure 1-16. Adjusting field artillery fires**

### Angle estimation

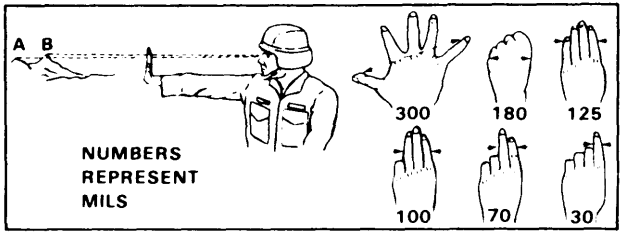



**Figure 1-17. Hasty method for estimating angle in mils**

### Quick Smoke

When using quick smoke consider the wind speed, wind direction, smoke duration required, and other friendly units in the area:

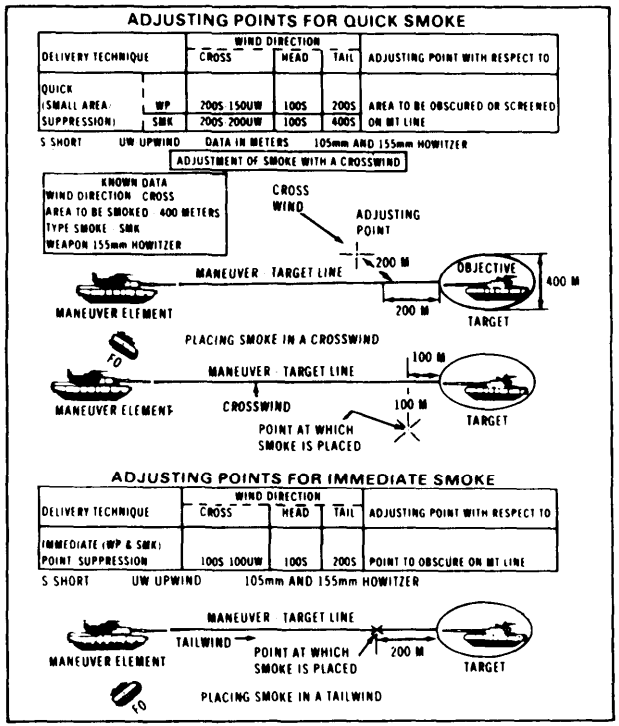



**Figure 1-18. Adjusting points for quick smoke**

**Table 1-3. Artillery and mortar smoke**

| DELIVERY SYSTEM | TYPE ROUND | TIME TO BUILD EFFECTIVE SMOKE | AVERAGE BURNING TIME | AVERAGE OBSCURATION LENGTH (METERS) PER ROUND WIND DIRECTION | | |
|---|---|---|---|---|---|---|
| | | | | CROSS | QUARTERING | HEAD/TAIL |
| 155MM | WP | ½ min | 1-1½ min | 100 | 75 | 50 |
| | HC | 1-1½ min | 4 min | 350 | 250 | 75 |
| 105MM | WP | ½ min | 1-1½ min | 75 | 60 | 50 |
| | HC | 1-1½ min | 3 min | 250 | 175 | 50 |
| 107MM | WP | ½ min | 1 min | 200 | 80 | 40 |
| 81MM | WP | ½ min | 1 min | 100 | 60 | 40 |

**Table 1-4. Artillery and mortar flares**

| TYPE WEAPON/ROUND | RANGE (METERS) | ILLUM TIME (SEC) | CONTINUOUS ILLUM (RD PER MIN) | DIAMETER OF ILLUM AREA (METERS) | CANDLEPOWER |
|---|---|---|---|---|---|
| 81MM/M301A3 | 3.300 | 75 | 2 | 1.100 | 500.000 |
| 107MM/M335A2 | 5.500 | 90 | 2 | 1.500 | 850.000 |
| 105MM/M314 | 8.500 | 60 | 2 | 1.000 | 600.000 |
| 155MM/M118 | 11.600 | 60 | 2 | 1.000 | 500.000 |
| 155MM/M485 | 14.000 | 120+ | 1 | 2.000 | 1.000.000 |

EXAMPLE

QUICK SMOKE

"M6J41 this is B5T36 adjust fire fire for effect over"
"Grid BS (612$^{AF}$327) (6122$^{FFE}$3275) direction 1600 over"
"Enemy observation post HC smoke in effect over"

Table 1-5. Fire support equipment characteristics

1. Ammunition

| TYPE | TYPICAL TARGETS |
|---|---|
| HE | personnel, light armor, crew weapons |
| HEAT/HEP-T (105 only) | light armor, light skin vehicle |
| ICM | personnel, light armor, light skin vehicle |
| DPICM (dual purpose) | all targets |
| APERS (105 only) | personnel |
| WP | vehicles, fuel/ammo stores (Also used as quick smoke.) |
| smoke | screening |
| ILLUM | night/darkness |
| copperhead | armor, point targets |
| RAP (rocket assist) | long range area targets |
| Scatterable mines (ADAMS/RAAMS) | mines, area denial (long and short duration) |
| nuclear | |
| chemical | |

2. Fuzes

| TYPE | TYPICAL TARGETS |
|---|---|
| impact (quick) | surface targets |
| delay | cratering, heavily wooded |
| mechanical time | dug-in, defilade positions |
| proximity (VT) | dug-in, defilade positions |
| concrete piercing | bunkers |

3. Weapon system maximum ranges

| WEAPON | RANGE |
|---|---|
| 81MM mortar | 4,595M |
| 4.2-inch mortar | 6,840M |
| 105MM | 11,500M |
| | 15,100M w/RAP |
| 155M (self propelled) | 18,100M |
| | 24,000M w/RAP |
| 155MM (towed) | 18,150M |
| | 30,000M w/RAP |
| 8 inch (203MM) | 22,900M |
| | 30,000M w/RAP |
| MLRS | +30,000M |

## Chemical Agents

### Table 1-6. Chemical agents characteristics and defense

| TYPE OF AGENT | HOW NORMALLY DISSEMINATED | MEANS OF DETECTION | SYMPTONS IN SOLDIER | EFFECT ON SOLDIER | RATE OF ACTION | INDIVIDUAL | | PROTECTION REQUIRED | U.S. AGENTS EQUIVALENT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | FIRST AID | DECONTAMINATION | | SYMBOL/NAME | FIELD CHARACTERISTICS |
| NERVE | Aerosol or vapor | Automatic chemical agent alarm and chemical agent detector kits to detect vapors and aerosols; chemical agent detector paper to detect liquids | Difficult breathing, drooling, nausea, vomiting, convulsions, and sometimes dim vision. | Incapacitates; kills if high concentration is inhaled. | Very rapid by inhalation; slow through skin. | Give nerve agent antidote injection. Artificial respiration may be necessary. | Nonpersistent. None needed. | Protective mask and protective clothing. | GA/Tabun<br>CB/Sarin<br>GD/Soman | Colorless |
| | Liquid droplet | | | Incapacitates; kills if contaminated skin is not decontaminated rapidly. | Delayed through skin, more rapid through eyes. | | Persistent. Flush eyes with water. Decontaminate skin using M258A1 Kit. | | VX<br>Thickened G-agent | |
| BLISTER | Liquid droplet | | Mustard, nitrogen mustard-no early symptoms. Lewisite, mustard-lewisite-searing of eyes and stinging of skin. Phosgene oxime-irritation of eyes and nose. | Blisters skin, is destructive to respiratory tract; can cause temporary blindness. Some agents sting and form wheals on skin. | Blistering delayed hours to days, eye effects more rapid. Mustard lewisite and phosgene oxime very rapid. | None | Flush eyes with water. Decontaminate skin with M258A1 Kit or wash with soap and water. | Protective mask and protective clothing. | HD/Mustard<br>HN/Nitrogen Mustard<br>L/Lewisite<br>HL/Mustard-Lewisite CX<br>Phosgene Oxime | Pale yellow droplets<br>Dark droplets<br>Dark, oily droplets<br>Dark, oily droplets<br>Colorless droplets |
| BLOOD | Vapor (gas) | | Convulsions and coma. | Incapacitates; kills if high concentration is inhaled. | Rapid | Mask. Artificial respiration may be necessary. | None | Protective mask. | AC/Hydrogen cyanide<br>CK/Cyanogen chloride | Colorless |
| CHOKING | Vapor (gas) | | Coughing, choking, nausea, and headache. | Damages and floods lungs. | Immediate to 3 hours. | For severe symptoms, avoid movement and keep warm. | None | Protective mask. | CG/Phosgene | Colorless |

**MEANING OF LINE ITEMS IN NBC REPORTS**

| LINE | NUCLEAR | CHEMICAL AND BIOLOGICAL | REMARKS |
|---|---|---|---|
| A | Strike serial number. | Strike serial number. | Assigned by division NBC Center. |
| B | Position of observer. | Position of observer. | Use grid coordinates (or place). |
| C | Direction of attack from observer. | Direction of attack from observer. | Direction measured clockwise from grid north or magnetic north (state which) in degrees or mils (state which). |
| D | Date-time group for detonation. | Date-time group for start of attack. | Zulu time. |
| E | Illumination time. | Date-time group for end of attack. | Zulu time (second). |
| F | Location of area attacked. | Location of area attacked. | Use grid coordinates (UTM or GEOREF) or place name. State whether location is actual or estimated. |
| G | Means of delivery. | Kind of attack. | State whether attack was by artillery, mortars, multiple rockets, missiles, bombs, or spray. |

| LINE | NUCLEAR | CHEMICAL AND BIOLOGICAL | REMARKS |
|---|---|---|---|
| H | Type of burst. | Type of agent/height of burst. | Estimate height of burst. Specify air, surface, or unknown for nuclear. State whether it was a ground or air burst for chemical. |
| I | NA | Number of munitions or aircraft. | If known. |
| J | Flash-to-bang time. | NA | Use seconds. |
| K | Crater present or absent and diameter. | Description of terrain and vegetation. | Nuclear: Send in meters. Chemical: Sent in NBC 6. |
| L | Cloud width at H+5. | NA | State whether measured in degrees or mils. |
| M | Stabilized cloud top or cloud bottom angle at H+10, or cloud or bottom top height. | Enemy action before and after attack. Effect on troops. | Nuclear: State whether angle is measured in degrees or mils, or whether height is measured in meters of feet. Chemical: Sent in NBC 6. |
| N | Estimated yield. | NA | Sent as KT. |
| O | Date-time group for contour lines. | NA | Used when contours are not plotted at H+1. |

| LINE | NUCLEAR | CHEMICAL AND BIOLOGICAL | REMARKS |
|---|---|---|---|
| P | Radar purposes only. | NA | |
| PA | Coordinates of external contours of radioactive cloud. | Predicted hazard area. | Chemical: If windspeed is 10 kmph or less, this item is 010 the radius of the hazard area in km. |
| PB | Downwind direction of radioactive cloud. | Duration of hazard. | Nuclear: State whether direction is in degrees or mils. Chemical: In days. |
| Q | Location of reading. | Location of sampling and type of sample. | Chemical: State whether test was air or liquid. |
| R | Dose rate. | NA | State in cGyph. See sample NBC 4 for terms associated with this line. |
| S | Date-time group of reading. | Date-time group contamination detected. | State time initial identification test sample or reading was taken. |
| T | H+1 date-time group. | Date-time group of latest contamination survey of the area. | NBC 5 and NBC 6 reports only. |

Figure 1-19. Line item definitions

| MEANING OF LINE ITEMS IN NBC REPORTS | | | | | | | |
|---|---|---|---|---|---|---|---|
| LINE | NUCLEAR | CHEMICAL AND BIOLOGICAL | REMARKS | LINE | NUCLEAR | CHEMICAL AND BIOLOGICAL | REMARKS |
| U | 1000-cGyph contour line. | NA | Plot in red. | ZA | NA | Significant weather phenomena. | See CDM for explanation of codes. |
| V | 300-cGyph contour line. | NA | Plot in green. | ZB | NA | Remarks. | Include any additional information. |
| W | 100-cGyph contour line. | NA | Plot in blue. | ZI | Effective wind speed. | NA | 3 digits (kmph). |
| X | 20-cGyph contour line. | Area of actual contamination. | Plot in black for nuclear, yellow for chemical. | | Downwind distance of zone I. | | 4 digits (hundreds of meters). |
| Y | Direction of left and right radial lines. | Downwind direction of hazard and windspeed. | Direction: 4 digits (degrees or mils). Windspeed: 3 digits (kmph or knots). | | Downwind distance of zone II. | | 4 digits (hundreds of meters). |
| Z | Effective wind speed. | NA | 3 digits (kmph or knots). | | Cloud radius. | | 3 digits (hundreds of meters). |
| | Downwind distance of zone I. | | 3 digits (km or Nm). | | | | |
| | Cloud radius. | | 2 digits (km or Nm). If windspeed is less than 8 kmph, this line contains only the 3-digit radius of zone I. | | | | |

Figure 1-19. Line item definitions (continued)

| NBC 1 (OBSERVER'S REPORT) | | | |
|---|---|---|---|
| LINE | NUCLEAR | CHEMICAL | BIOLOGICAL |
| B | NB062634 | LB200300 | LB206300 |
| C | 90 Deg Grid | | |
| D | 201405Z | 201405Z | 200410Z |
| E | | 201412Z | 20G414Z |
| F | | LB206300 Est | LB206300 Act |
| G | Aircraft | Bomblets | Aerial Spray |
| H | Surface | Nerve. V. Air Burst | Unknown |
| J | 60 Sec | | |
| L | 15 Deg | | |
| M | | | |

**NOTE:** Line items B, D, H and either C or F should always be reported, other line items may be used if the information is known.

| NBC 2 REPORT (EVALUATED DATA) | | | |
|---|---|---|---|
| LINE | NUCLEAR | CHEMICAL | BIOLOGICAL |
| A | A024 | B002 | C001 |
| D | 201405Z | 200945Z | 201395Z |
| F | LB187486 Act | LB126456 Act | LB206300 Act |
| G | Aircraft | Bomblets | Unknown |
| H | Surface | Nerve. V. Air Burst | Unknown |
| N | 50 | | |
| Y | | 0270 Deg. 015 kmph | |
| ZA | | 518640 | |

**NOTES:** 1. This report is normally based on two or more NBC 1 reports. It includes an attack location and, in the case of a nuclear detonation an evaluated yield.

2. Refer to the chemical downwind message to determine cloud cover significant weather phenomena and air stability.

| NBC 3 REPORT (IMMEDIATE WARNING OF EXPECTED CONTAMINATION) | | |
|---|---|---|
| LINE | NUCLEAR | CHEMICAL |
| A | A024 | B002 |
| D | 201405Z | 201415Z |
| F | LB187486 Est | LB560750 Act |
| H | | Nerve. V. Air Burst |
| N | 50 | LB556751 |
| PA | | LB559754 |
| | | LB632774 |
| | | LB610794 |
| | | LB558747 |
| PB | | In attack area 2-4 days |
| | | In hazard area 1-2 days |
| Y | 02720312 | 0270 Deg. 015 kmph |
| Z | 01902505 | |
| ZA | | 518640 |
| ZI | 010. 0017. 0028. 007 | |

**NOTES:** 1. If the effective windspeed is less than 8 kmph, line Z of the NBC 3 (nuclear) consists of three digits for the radius of zone I.

2. If the windspeed is less than 10 kmph, line PA of the NBC 3 (chemical ) is 010 which is the radius of the hazard area.

3. Line ZI is used for NUCWARN reports. When line ZI is used, line Z is not used

**Figure 1-20. NBC reports**

| NBC 4 REPORT (RECONNAISSANCE, MONITORING, AND SURVEY RESULTS) | | |
|---|---|---|
| LINE | NUCLEAR | CHEMICAL |
| H | | Nerve, V |
| Q | LB123987 | LB200300, Liquid |
| R | 35 | |
| S | 201535Z | 170610Z |

NOTES: 1. Line items H, Q, R, and S may be repeated as often as necessary.
2. Radiation dose rates are measured in the open, with the instrument 1 meter above the ground.
3. In line R, descriptive words such as initial, peak, increasing, decreasing, special, series, verification, or summary may be added.
4. If readings are taken inside a vehicle or shelter, also give the transmission factor.

| NBC 5 REPORT (AREAS OF ACTUAL CONTAMINATION) | | |
|---|---|---|
| LINE | NUCLEAR | CHEMICAL |
| A | A0012 | B005 |
| D | | 200700Z |
| H | | Nerve, V, Air Burst |
| S | | 201005Z |
| T | 201505Z | 201110Z |
| U | | |
| V | ND651455 | |
| | ND810510 | |
| | ND821459 | |
| | ND651455 | |
| W | ND604718 | |
| | ND991686 | |
| | ND114420 | |
| | ND595007 | |
| X | | ND206991 |
| | | ND201576 |
| | | ND200787 |
| | | ND206991 |

NOTE: This report is best sent as an overlay, if time and the tactical situation permits.

| NBC 6 REPORT (DETAILED INFORMATION ON CHEMICAL OR BIOLOGICAL ATTACKS) | |
|---|---|
| LINE | CHEMICAL OR BIOLOGICAL |
| A | B001 |
| D | 200945Z (May) |
| E | 200950Z (May) |
| F | LB200300, Act |
| G | Artillery |
| H | Nerve, V, Air Burst |
| I | 20 rounds |
| K | Mostly small houses and barns, elevation 600 meters |
| M | Attack received as counterfire, enemy bypassed on right flank of attack area |
| Q | Liquid ground sample taken by detection team in attack area |
| S | 201005Z (May) |
| T | 201110Z (May) |
| X | As per overlay |
| Y | Downwind direction 0090 degrees, windspeed 010 kmph |
| ZB | This is the only chemical attack in our area to date |

NOTES: 1. This report is submitted only when requested.
2. This report is completed by battalion and higher NBC personnel. It is in narrative form, giving as much detailed information as possible for each line item.

Figure 1-20. NBC reports (continued)

## Alarms, Signals, and Warnings

### Alarms and signals

Table 1-7. Alarms and signals

| TYPE | CHEMICAL/ BIOLOGICAL | NUCLEAR |
|---|---|---|
| Vocal | Gas or Spray | Fallout |
| Sound | Succession of short signals<br>— Metal to metal<br>— Short horn blasts<br>— Interrupted warbling siren | |
| Visual | Fists over shoulder or posted signs | |
| Audio/Visual | M8 or M8A1 | |

## Mission-Oriented Protection (MOPP) Levels

Table 1-8. MOPP levels

| MOPP LEVEL | OVERGARMENT | OVERBOOTS | MASK/ HOOD | GLOVES |
|---|---|---|---|---|
| 0 | Readily Available | Readily Available | Carried | Readily Available |
| 1 | Worn* | Carried | Carried | Carried |
| 2 | Worn* | Worn | Carried | Carried |
| 3 | Worn* | Worn | Worn* | Carried |
| 4 | Worn Closed | Worn | Worn Closed | Worn |

*Overgarment and/or hood worn open or closed based upon the temperature.

### Friendly warnings

See Figure 1-21 for warnings and Figure 1-22 for protection requirements for friendly nuclear strikes.

CHEMWARN (FRIENDLY CHEMICAL STRIKE)

| | |
|---|---|
| A | AF002Chem |
| D | 028030Z |
| F | PG560750 |
| G | Artillery Ground Burst |
| H | Nonpersistent Nerve |
| PA | PG556751<br>PG559754<br>PG632774<br>PG610694<br>PG558747 |
| Y | 0015 Deg. 15 kmph |

NOTE: A CHEMWARN message is plotted like an NBC 3 (chemical) report.

CHEMWARN FORMAT

| LINE | MEANING | REMARKS |
|---|---|---|
| A | Strike serial number or code word. | Indicate this is a chemical attack. |
| D | Date-time group of attack. | Only the date and time of the attack given. This should be encoded. |
| F | Location of attack. | Grid coordinates of center of attack. If attack is spread over a large area, a series of coordinates may be given to indicate the center of mass of the attack. This should be encoded. |
| G | Delivery means. | Tell how delivered and how disseminated. |
| H | Type of agent. | Classify agent by physiological effect and duration of effectiveness. |
| PA | Attack area and predicted hazard area. | When windspeeds are 10 kmph or less this line will be 010, which is the radius of hazard area in km. When windspeeds are greater than 10 kmph, 6-digit coordinates will be given. |
| PB | Duration of hazard. | In days. |
| Y | Downwind direction. Windspeed. | 4 digits in degrees or mils (state which). 2 digits in kmph. |

Figure 1-21. Friendly NBC warnings

NUCWARN (FRIENDLY NUCLEAR STRIKE)

| LINE | MULTIPLE | SINGLE |
|---|---|---|
| A | Lamp Post | AC002 |
| D | 162025Z-162155Z | 270915Z-270930Z |
| F2 | PA613423 | |
| | PA616515 | |
| | PA655523 | |
| | PA631450 | |
| | PA625413 | |
| F3 | PA602403 | 011 PA215154 |
| | PA605536 | |
| | PA672552 | |
| | PA642472 | |
| | PA673442 | |
| H | 3 Surface | Surface |
| I | 22 | |

NOTE: If the burst is to be a surface burst, an NBC 3 (nuclear) report (containing line ZI) should be prepared for separate transmission.

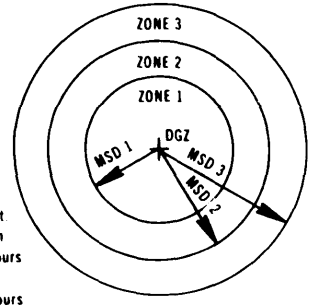
NUCWARN FORMAT

| LINE | MEANING | REMARKS |
|---|---|---|
| A | Target number or code. | Use target number, such as AF001, for single attack. Use code, or nickname such as Hot Candle, for multiple attacks. |
| D | Date-time groups. | Single: Date and time attack will begin and the date and time attack will end. Multiple: Date and time attack will begin and date and time when all bursts will be complete. This line should be encoded. |
| F1 | Minimum safe distance 1 (MSD 1) and location of single attack. | If all troops are outside MSD 3, only F3 is transmitted. This line should be encoded. Multiple: Appears as a series of coordinates that define an MSD box plotted around the MSD for each burst in the group. Single: Distance in meters from ground zero to the edge of zone 1, followed by grid coordinates for attack location. |
| F2 | MSD 2. | Same as F1 except information pertains to MSD 2. |
| F3 | MSD 3. | Same as F1 except information pertains to MSD 3. |
| H | Type and number of bursts (surface or subsurface only). | If there is any chance the strike will be a surface or subsurface burst this line is sent. |
| I | Number of bursts. | For multiple bursts only. |

Figure 1-21. Friendly NBC warnings (continued)

PROTECTION REQUIREMENTS FOR FRIENDLY NUCLEAR STRIKE

| AREA | NEGLIGIBLE RISK TO | ZONE OF WARNING | PROTECTION REQUIREMENT |
|---|---|---|---|
| DGZ to MSD 1 | NA | 1 | Evacuate all personnel. |
| MSD 1 to MSD 2 | Warned, protected personnel. | 2 | Personnel in buttoned-up tanks or foxholes with overhead cover. |
| MSD 2 to MSD 3 | Warned, exposed personnel. | 3 | Personnel prone on ground with all skin covered. |
| MSD 3 and beyond | Unwarned, exposed personnel. | NA | No protective measures except dazzle. |




SIGNIFICANCE OF PREDICTED FALLOUT ZONES

Exposed, unprotected people may receive the following doses from fallout.

Zone I—Immediate operational concern
More than 150 cGy within 4 hours

Zone II—Secondary hazard.
Less than 150 cGy within 4 hours
More than 50 cGy within 24 hours

Outside the predicted area—
No more than 50 cGy in 24 hours
No more than 150 cGy for an indefinite period

Figure 1-22. Protection for nuclear strikes

## NBC WEATHER/WIND MESSAGES

### EFFECTIVE DOWNWIND MESSAGE

| ZULU | DDTTTT | DATE-TIME GROUP WINDS WERE MEASURED (ZULU) |
|---|---|---|
| ALFA | dddsss--- | Over 0 thru 2 KT |
| BRAVO | dddsss--- | Over 2 thru 5 KT |
| CHARLIE | dddsss--- | Over 5 thru 30 KT |
| DELTA | dddsss--- | Over 30 thru 100 KT |
| ECHO | dddsss--- | Over 100 thru 300 KT |
| FOXTROT | dddsss--- | Over 300 thru 1 MT |
| GOLF | dddsss--- | Over 1 thru 3 MT |

NOTES: 1. The first three digits (ddd) give the effective wind direction, in degrees, from grid north.
2. The second three digits (sss) give the effective wind speed in kilometers per hour.
3. The last three digits (---) give the expanded angle in degrees.

### CHEMICAL DOWNWIND MESSAGE

CDM

| | |
|---|---|
| 110500 Zulu | 110600 Zulu |
| I Corps | |
| WHISKEY | 120010 418742 |
| XRAY | 125919 416742 |
| YANKEE | 130005 518642 |

NOTES: 1. CDM is only valid for 6 hours.
2. Area affected may be a mapsheet number or an area such as I CORPS.
3. Lines WHISKEY, XRAY, and YANKEE each contain coded weather information. Line WHISKEY is only valid for the first two hours; line XRAY for the next two hours; and line YANKEE for the last two hours.

## HOW TO READ THE WEATHER INFORMATION IN A CHEMICAL DOWNWIND MESSAGE

WHISKEY 120 010 4 18 7 4 2

**Downwind direction in degrees** (120)

**Wind speed in kmph** (010)

**Air stability code** (4)
- 1 = very unstable (U)
- 2 = unstable (U)
- 3 = slightly unstable (U)
- 4 = neutral (N)
- 5 = slightly stable (S)
- 6 = stable (S)
- 7 = very stable (S)

**Cloud cover code** (2)
- 0 - Sky less than half covered by clouds
- 1 - Half the sky covered by clouds
- 2 - More than half the sky covered by clouds

**Temperature code** (18)

| Code | Temp |
|---|---|
| 05 | 5°C |
| 04 | 4°C |
| 03 | 3°C |
| 02 | 2°C |
| 01 | 1°C |
| 00 | 0°C |
| 51 | -1°C |
| 52 | -2°C |
| 53 | -3°C |
| 54 | -4°C |
| 55 | -5°C |

**Humidity code** (7)
- 0 - 0 - 9%
- 1 - 10 - 19%
- 2 - 20 - 29%
- 3 - 30 - 39%
- 4 - 40 - 49%
- 5 - 50 - 59%
- 6 - 60 - 69%
- 7 - 70 - 79%
- 8 - 80 - 89%
- 9 - 90 - 99%

**Significant weather phenomena code** (4)
- 3 - Blowing snow or sand
- 4 - Fog, ice fog, or thick haze
- 5 - Drizzle
- 6 - Rain
- 7 - Light rain or snow
- 8 - Showers of rain, snow, hail or a mixture
- 9 - Thunderstorm

Figure 1-23. NBC downwind messages

Correlation and transmission factors

**CORRELATION FACTORS FOR RESIDUAL RADIATION**

| ENVIRONMENTAL SHIELDING VEHICLES | LOCATION OF SURVEY METER | CORRELATION FACTOR |
|---|---|---|
| M1 Tank | | 20 |
| M60 Tank | Turret, rear top | 25 |
| | Turret, front | 53 |
| M2 IFV | Chassis, near driver | 23 |
| M3 CFV | | 9.1 |
| M113 APC | Directly in front of driver on front wall | 9.1 |
| | | 3.6 |
| | Near first squad member on left facing forward | 3.6 |
| M109 SP howitzer | Near driver, left side | 3.5 |
| | Rear, right side | 3.4 |
| M88 Recovery vehicle | Commander position | 6.9 |
| M577 Command post carrier | Near driver, right side | 3.2 |
| | Rear, left side | 2.5 |
| M551 Armored recon abn assault vehicle | Near driver, right side | 4.6 |
| TRUCKS | | |
| ¼-ton | | 1.3 |
| ¾-ton | | 1.7 |
| 2-½-ton | | 1.7 |
| 4-ton to 7-ton | | 2 |
| STRUCTURES | | |
| Multistory building | | |
| Top floor | | 100 |
| Lower floor | | 10 |
| Frame house | | |
| First floor | | 2 |
| Basement | | 10 |
| UNDERGROUND SHELTER (3-foot earth cover) | | 5,000 |
| FOXHOLES | | 10 |

**TRANSMISSION FACTORS FOR RESIDUAL RADIATION**

| ENVIRONMENTAL SHIELDING | TRANSMISSION FACTOR (FT) |
|---|---|
| VEHICLES | |
| M1 Tank | 0.04 |
| M60 Tank | 0.04 |
| M2 IFV | 0.2 |
| M3 CFV | 0.2 |
| M113 APC | 0.3 |
| M109 SP howitzer | 0.2 |
| Sgt York gun | 0.02 |
| M548 Cargo vehicle | 0.7 |
| M88 Recovery vehicle | 0.09 |
| M577 Command post carrier | 0.3 |
| M551 Armored recon abn assault vehicle | 0.2 |
| M728 Combat engr vehicle | 0.04 |
| TRUCKS | |
| ¼-ton | 0.8 |
| ¾-ton | 0.6 |
| 2-½-ton | 0.6 |
| 4-ton to 7-ton | 0.5 |
| STRUCTURES | |
| Multistory building | |
| Top floor | 0.01 |
| Lower floor | 0.1 |
| Frame house | |
| First floor | 0.6 |
| Basement | 0.1 |
| URBAN AREA (in open) | 0.7* |
| WOODS | 0.8* |
| UNDERGROUND SHELTER (3-foot earth cover) | 0.0002 |
| FOXHOLES | 0.1 |

$$\text{Transmission factor (TF)} = \frac{\text{Inside dose rate (ID)}}{\text{Outside dose rate (OD)}} \quad \text{or} \quad \text{OD} = \frac{\text{ID}}{\text{TF}} \quad \text{or ID} = \text{TF} \times \text{OD}$$

*These factors do not apply to ground survey dose rates.

Figure 1-24. Correlation and transmission factors

## NBC Markers

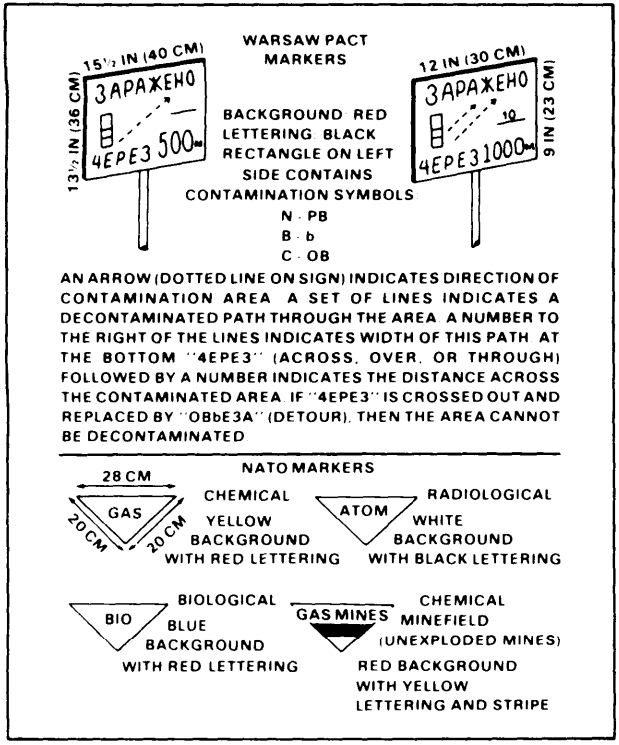



Figure 1-25. NBC markers

## Unmasking Procedures

**With detector kit**

Use a Chemical Agent Detector Kit (M256) to test for the presence or absence of chemical agents. After determining the absence of agents, use the following steps to check for chemical agent symptoms.

- Unmask two or three individuals for five minutes and then remask.
- Examine in a shady area for chemical agent symptoms for 10 minutes.
- Unmask remainder of troops if no symptoms appear.

NOTE: Bright light will cause contraction of the pupils which could be erroneously interpreted as a nerve-agent symptom.

**Without detector kit**

Use the following steps for field expedient unmasking:

- Select two or three individuals to take a deep breath, hold it then break the seal on the masks. Keep their eyes wide open for 15 seconds. Clear the masks and reestablish the seal.
- Wait for 10 minutes. Watch for symptoms.
- If no symptoms develop, break the seal of their mask and have them take two or three breaths. Clear and reseal the masks.
- Observe for symptoms for 10 minutes. If no symptoms were observed, unmask same individuals for five minutes and remask.
- Observe them another 10 minutes for possible symptoms If no symptoms develop in 10 minutes, the group can safely unmask.

Remain alert for the appearance of any chemical agent symptoms.

Table 1-9. Engineer company degradation factors

| MAJOR FUNCTION | DESCRIPTION | WORK-LOAD | TIMES REQUIRED TO ACCOMPLISH FUNCTIONS | | | |
|---|---|---|---|---|---|---|
| | | | WITHOUT PROTECTIVE CLOTHING | WHILE IN MOPP4 | | |
| | | | | @20°F (-7°C) | @50°F (10°C) | @85°F (29°C) |
| Secure site | Organize work area. | Light | 15 min | 15 min | 15 min | 25 min |
| Reconnaissance | For obstacle locations, time from start till ready to order materials | Light to Moderate | 45 min | 45 min | 45 min | 105 min |
| | For Class 50 or more bridge (to handle tank traffic) | Light to Moderate | 3 hr | 3 hr | 3 hr | 7 hr |
| | For assault bridge (to cross river or ditch) | Light to Moderate | 2 hr | 2 hr | 2 hr | 6 hr |
| | For large gully without water | Light to Moderate | 30 min | 30 min | 30 min | 90 min |
| Prepare hull defilade position, per tank per digging vehicle (Note 2) | Dirt berm around tank | Moderate | 30 min | 30 min | 30 min | 90 min |
| Dig tank ditch, two digging vehicles in any combination | 3.2M wide x 1.8M deep | Moderate | 2.5 hr/ 100M length | 2.5 hr/ 100M length | 2.5 hr/ 100M length | about 7.0 hr/ 100M length |
| Minefield emplacement with M57 towed mine dispenser | 300M long x 50M deep (Note 2) | Moderate | 1 platoon hr | 1 platoon hr | 1 platoon hr | 3 platoon hr |
| By hand | 100M long x 100M deep (Note 3) | Heavy | 4 squad hr | 8 squad hr | 12 squad hr | 24 squad hr |
| Disable bridges | Four-lane highway<br>Two-lane primary road | Heavy<br>Heavy | 3 squad hr<br>2 squad hr | 6 squad hr<br>4 squad hr | 9 squad hr<br>6 squad hr | 18 squad hr<br>12 squad hr |

Table 1-9. Engineer company degradation factors (continued)

| MAJOR FUNCTION | DESCRIPTION | WORK-LOAD | TIMES REQUIRED TO ACCOMPLISH FUNCTIONS | | | |
|---|---|---|---|---|---|---|
| | | | WITHOUT PROTECTIVE CLOTHING | WHILE IN MOPP4 | | |
| | | | | @ 20°F (-7°C) | @ 50°F (10°C) | @ 85°F (29°C) |
| Build abatis. 30 trees. 25 to 35 cm in diameter | 40 meters deep with trees 3 meters apart | Heavy | 2 squad hr | 4 squad hr | 6 squad hr | 12 squad hr |
| Build road crater. average size (terrain dependent) | 50M long x 25M wide x 4M deep | Heavy | 2 squad hr | 4 squad hr | 6 squad hr | 12 squad hr |
| Breach wire | Hasty (with bangalore torpedo-footpath wide) | Heavy | 2 squad hr | 4 squad hr | 6 squad hr | 12 squad hr |
| Breach minefield | Using detector/probe 8 ft wide | Heavy | 1 platoon hr | 2 platoon hr | 3 platoon hr | 6 platoon hr |
| | With M157 demolition snake. 90M deep. 4 to 6M wide | Heavy | 2 squad hr | 4 squad hr | 6 squad hr | 12 squad hr |
| Bridging | Temporary fording (Note 4) | Heavy | 1 hr for equipment | 2 hr for equipment | 3 hr for equipment | 6 hr for equipment |
| | Ribbon bridge (Note 5) | Heavy | 5 min/bay | 10 min/bay | 15 min/bay | 30 min/bay |
| | Ribbon bridge. 100-foot length under ideal conditions (Note 6) | Heavy | 3 hr | 6 hr | 9 hr | 18 hr |
| | Bailey bridge. 25M long. ideal conditions | Heavy | 5.5 hr (7 hr in dark) | 11 hr | 16.5 hr | 33 hr |
| Mine emplacement. per soldier | Antitank | Heavy | 4 mines/hr | 4 mines/ 2 hr | 4 mines/ 3 hr | 4 mines/ 6 hr |
| | Antipersonnel. fragmentation | Heavy | 8 mines/hr | 8 mines/ 2 hr | 8 mines/ 3 hr | 8 mines/ 6 hr |
| | Antipersonnel. blast | Heavy | 16 mins/hr | 16 mines/ 2 hr | 16 mines/ 3 hr | 16 mines/ 6 hr |

NOTES: 1. Consists of three platoons of three squads each. Squads use one M113 (APC) and a 1.5-ton trailer. eight soldiers.

2. Requested by armor unit. Performed ahead of time. Dig hole large enough to hide tank.

3. Density of 0.5 mines/meter of front. Double times if density of 1 mine/meter of front is used.

4. Knock down banks. grade. add gravel. and so forth.

5. Ribbon bridge. Number of bays depend upon width of river. For each three bays. add 5 min for bridge erection boat.

6. Forty-two people (assume trained troops). Add 50 to 100 percent if dark. add 30 to 50 percent for bad weather. Add 20 percent if untrained troops.

## Decontamination

### Equipment

Use issued items whenever available for expedient decontaminations Table 1-10 shows some natural decontaminations.

**Table 1-10. Natural decontaminations**

(Decontaminations readily available and frequently occurring in nature)

| DECONTAMINATIONS | USE | REMARKS | CAUTIONS |
|---|---|---|---|
| WATER | NUC<br>BIO<br>CML | Flush contamination from surface with large amounts of water. | Effective in physically removing contamination, but does not neutralize the contamination. |
| STEAM | NUC<br>BIO<br>CML | The use of steam accompanied by scrubbing is more effective than the use of steam alone. | Effective in physically removing contamination. However, contamination may not be neutralized. |
| ABSORBENTS (earth, sawdust, ashes, rags, and similar materials) | CML | Used to physically remove gross contamination from surfaces | The contamination is transferred from the surface to the absorbent. The absorbent becomes contaminated and must be disposed of accordingly. Sufficient contamination to produce casualties may well remain on surfaces. |

### Personnel

Decontaminate personnel using the buddy system and the following procedure:

Step 1. Remove and decontaminate gear. Cover gear with super tropical bleach (STB) dry mix and brush or rub into material. Shake off excess. Set aside gear on uncontaminated surface.

Step 2. Decontaminate hood. Use M258A1 skin decontamination kit. Decontaminate exposed areas of protective mask. Use decontaminate wipe 2 first, then decontaminate wipe 1 to get rid of chances of residue from decontaminate wipes. Lift hood up off your buddy 's shoulder by grasping straps and pulling hood over head until back of head is exposed. Roll hood tightly around mask.

NOTE: Control contamination from spreading by putting all contaminated overgarments and towelettes in one pile.

Step 3. Remove overgarment. Remove buddy's jacket placing it on the ground, black side up. Remove trousers one leg at a time. Discard trousers in centralized pile to avoid contamination spread.

Step 4. Remove overboots and gloves. Cut strips off buddy's boots and pull off boots. Have buddy step onto jacket as boots are pulled off. Remove gloves. Discard boots and gloves into centralized pile.

Step 5. Put on overgarments. Open package of new overgarments. Do not touch overgarment. Have buddy dress while still standing on old overgarment (Step 3).

Step 6. Put on overboots and gloves. Open package of new boots and gloves. Do not touch them. Have buddy put on new boots and gloves. Buddy may step off overgarment once boots and gloves are on.

Step 7. Secure hood. Decontaminate your gloves using M258A1 skin decontamination kit. Unroll buddy's hood and attach straps. Buddy checks all zippers and ties on hood and overgarment to ensure they are closed.

Step 8. Reverse roles. Repeat Steps 2 through 7. Have your buddy help you through the steps.

Step 9. Dig a large hole. Place all contaminated clothing and discarded towelettes in hole and cover. Mark as contaminated area. Contaminated clothing can also be burned if slow burning fuel (kerosene or diesel fuel) is used. **DO NOT USE GASOLINE,** it burns too quickly. Commanders must warn downwind units of a possible downwind vapor hazard if burning is accomplished.

Step 10. Secure gear. Move to assembly area. If time and situation permits, unit may now perform unmasking procedure to obtain relief from protective mask.

## MEDICAL PROCEDURES

### Lifesaving Steps

- Open airway, restore breathing, and heartbeat.
- Stop the bleeding.
- Protect the wound.
- Prevent or treat for shock.

### Cardiopulmonary Resuscitation (CPR) Procedures

See Figure 1-26

### General First Aid Procedures

| PROBLEM | FIRST AID |
|---|---|
| Blocked airway | Extend neck, turn head to side and clear all refuse from mouth. |
| Bleeding | Direct pressure on wound with sterile dressing. Elevate wound above heart. Use tourniquet as last resort. |
| Wounds | Expose wound, control bleeding, apply sterile dressing and treat for shock. Do not clean wound. |
| Fractures | Splint the break where and how it lies. Do not move patient if possible. Immobilize joint above and below fracture. Cover exposed bones or open wounds. |
| Shock | Lay patient on back, elevate feet, loosen clothes, and keep warm. Feed hot liquids if conscious. Turn head to side if unconscious. |

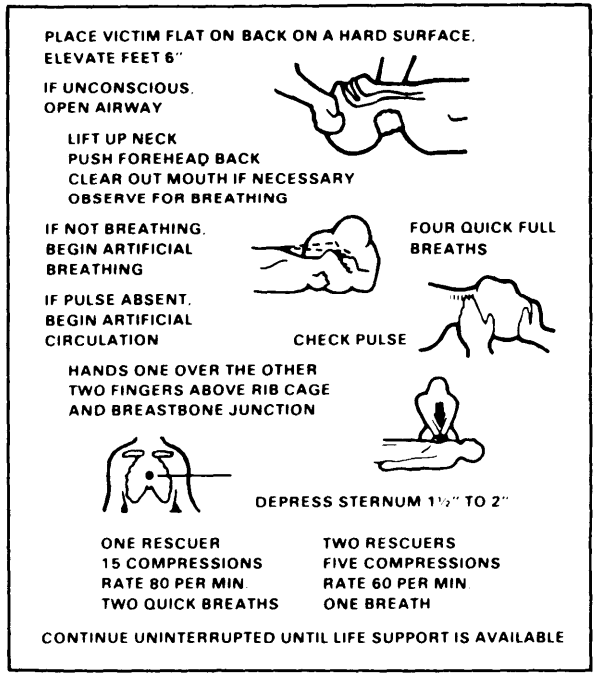



**Figure 1-26. Cardiopulmonary resuscitation in basic life support**

## Common Wounds and Injuries

**Head wound**

Symptoms. If scalp wound is not obvious, check for headaches, recent unconsciousness, blood or fluid from ears or nose, slow breathing, vomiting, nausea, and convulsions.

First aid. Leave any brain tissue as is and cover with sterile dressing. Secure dressing and maintain head higher than body.

**Jaw wound**

Slightly elevate head, clear the airway, control bleeding. and protect the wound. Position head to allow drainage from mouth. **DO NOT GIVE MORPHINE.** Treat for shock as needed.

**Belly wound.**

Leave all organs as they are and loosely place sterile dressing over them. Give no food or liquid. Leave victim on back with head turned to one side.

**Chest wound (sucking)**

Have victim breathe out and hold breath if possible. Seal wound airtight with plastic or foil. Cover with dry sterile dressing and secure with bandages around body. Wound must be airtight and fully covered.

## Burns and Heat Injuries

| PROBLEM | SYMPTOM | FIRST AID |
|---|---|---|
| Burns | First degree (red skin) Second degree (blistered skin) Third degree (destroyed tissue) | Do not remove clothes around burn area. Do not apply grease or ointment. Cover with sterile dressing. Give cool salt/soda water. |
| Heat cramps | Muscle cramps of abdomen, legs or arms. | Move person to shade and loosen clothing. Give victim large amounts of cold salt water slowly. Prepare salt water by dissolving two salt tablets or ¼ teaspoon of table salt in canteen of cool water. |
| Heat exhaustion | Headache, excessive sweating, weakness, dizziness nausea, and muscle cramps. Pale, cool, and moist clammy skin. | Lay person in cool shaded area and loosen clothing. If victim is conscious, have victim drink three to five canteens of cool salt water during period of 12 hours. Prepare salt water as described for heat cramps. |
| Heatstroke (sunstroke) | Stoppage of sweating (hot, dry skin). Collapse end unconsciousness may come suddenly or may be preceded by headache, dizziness, fast pulse, nausea, vomiting, and mental confusion. | Promptly immerse victim in coldest water possible. Add ice, if available to water. If victim cannot be immersed, move into shade, remove clothing, and keep wet by pouring water over entire body. Fan victim's wet body continuously. Transport victim to nearest medical facility at once, cooling victim's body on the way. If victim becomes conscious, give cool salt water prepared as described for "Heat cramps." |

## Wet or Cold Weather Injuries

| PROBLEM | SYMPTOM | FIRST AID |
|---|---|---|
| Frostbite | Skin is white, stiff, and numb. | Cover frostbitten part of face with warm hands until pain returns. Place frostbitten bare hands next to skin in opposite armpits. If feet are frostbitten, seek sheltered area and place bare feet under clothing and against abdomen of another person. If deep frostbite is suspected, protect part from additional injury and get to medical treatment facility immediately. DO NOT attempt to thaw deep frostbite. There is less danger of walking on feet while frozen than after thawed. |
| Immersion foot | Soles of feet are wrinkled. Standing or walking is extremely painful. | Dry feet thoroughly and get to medical treatment facility immediately. Avoid walking if possible. |
| Trench foot | Numbness may be tingling or aching sensation, cramping, pain and swelling | Same as immersion foot above. |
| Snow blindness | Scratchy feeling in eyes | Cover eyes with dark cloth. Transport victim to medical treatment facility at once. |

## Stings and Bites

| PROBLEM | FIRST AID |
|---|---|
| Black widow spider or brown recluse spider bite | Keep victim quiet. Place ice or freeze-pack, if available, around region of body where bite occurred to keep venom from spreading. Transport victim to medical treatment facility immediately. |
| Scorpion sting or tarantula bite | For ordinary scorpion string or tarantula bite, apply ice or freeze pack if available. Baking soda applied as paste to site may relieve pain. If site of sting or bite is on face, neck or genital organs or if sting is by scorpion of dangerous types found in South America, keep victim as quiet as possible and transport to medical treatment facility immediately. |
| Snake bite | Reassure victim and keep victim quiet. Place ice or freeze pack, if available, around region of body where bite occurred. Immobilize affected part in position below level of heart. If bite is on arm or leg, place lightly constricting band (bootlace or strip of cloth) between bite site and heart at point 2 to 4 inches above bite site. Apply band tight enough to stop blood flow near skin but NOT tight enough to stop arterial flow or the pulse. Transport victim to medical treatment facility at once. Kill snake (if possible without damaging its head) and evacuate with victim. |
| Bee or wasp bite | Treatment not usually required. Treat for shock if abnormal reactions occur. |

## Other Conditions

| PROBLEM | FIRST AID |
|---|---|
| Blisters | DO NOT open blisters unnecessarily, as they are sterile until opened. If you must open blister, be cautious. Wash part thoroughly with soap and water, then apply antiseptic to skin. Sterilize a needle in the open flame of a match. Use a sterile needle, puncture blister at the edge. Use a sterile gauze pad, apply pressure along margin of blister, thus removing fluid. Place a sterile dressing over the area. DO NOT attempt self help for blisters in the center palm of hand. |
| Boils | DO NOT squeeze a boil, as this may drive bacteria into the blood stream and cause internal abscesses or bone infection. This is especially unwise if boil is around nostrils, upper lip, or around the eyes. In these areas the blood stream leads to brain area. Relieve discomfort from small boils by applylng warm compresses wet in Epsom salt solution (1 teaspoon salt to pint of warm water) at 15-minute intervals. DO NOT apply these compresses to facial boils unless under medical direction. If boil breaks, wipe pus away with sterile pad wet with rubbing alcohol. Work from healthy skin toward boil and pus. Apply sterile dressing over boil. |
| Unconsciousness | Apply lifesaving measures as appropriate. If victim remains unconscious, place on abdomen or side with head turned to one side to prevent choking on vomitus, blood, or other fluid. If victim has abdominal wound, place on back with head turned to one side. Get victim to medical treatment facility immediately. DO NOT give victim fluids by mouth while unconscious. If the victim has merely fainted, victim will regain consciousness within a few minutes. If ammonia inhalant capsule is available, break it and place under the victim's nose several times for a few seconds. If victim is sitting up, gently lay down, loosen clothing, apply cool wet cloth to face. Let victim lie quietly. Anytime a person in sitting position is about to faint, lower the victim's head between knees and hold the victim to prevent falling. |

## Medical Evacuation (MEDEVAC)

### Precedence

| | |
|---|---|
| URGENT | Evacuation is required as soon as possible but not later than two hours to save life, limb, or eyesight. |
| PRIORITY | Evacuation is required within four hours or the patient's medical condition could deteriorate to an URGENT precedence. |
| ROUTINE | Evacuation is required within 24 hours. |
| TACTICAL IMMEDIATE | The patient's medical condition is not URGENT or PRIORITY but evacuation is required as soon as possible so as not to endanger the unit's tactical mission. |

### Types

| TYPE | USE | REMARKS |
|---|---|---|
| Peacetime | Actual patient | May be transmitted in plain text |
| Wartime | During wartime or training exercises | Must be transmitted secured or encrypted. |

**MEDEVAC request format**

See Table 1-11 (pages 1-32 through 1-34).

Table 1-11. MEDEVAC request format

| LINE | ITEM | EXPLANATION | WHERE/HOW OBTAINED | WHO NORMALLY PROVIDES | REASON |
|---|---|---|---|---|---|
| 1 | Location of pickup site. | Encrypt the grid coordinates of the pickup site. When using the DRYAD Numeral Cipher, the same SET line will be used to encrypt both the grid zone letters and the coordinates. To preclude misunderstanding, a statement should be made that grid zone letters are included in the message. (Unless unit SOP specifies its use at all times.) | From map | Unit leader(s) | Required so evacuation vehicle knows where to pick up casualty/patient and so that the unit coordinating the evacuation mission can plan route for the evacuation vehicle (if the evacuation vehicle must pick up from more than one location.) |
| 2 | Radio frequency, call sign, and suffix | Encrypt the frequency of the radio at the pickup site, not a relay frequency. The call sign (and suffix if used) of person to be contacted at the pickup site may be transmitted in the clear. | From CEOI | RTO | Required so that evacuation vehicle can contact requesting unit while en route to obtain additional information, such as change in situation and direction. |
| 3 | Number of patients by precedence | Report only applicable information and encrypt the appropriate amount(s) and brevity numbers.<br>(#) - 1 - URGENT.<br>(#) - 2 - PRIORITY.<br>(#) - 3 - ROUTINE.<br>If two or more categories must be reported in the same request, insert the word BREAK between each category. | From evaluation of patient(s) | Medic or senior person present | Required by unit controlling the evacuation vehicles to assist prioritizing missions when more than one is received. |
| 4 | Special equipment required | Encrypt the appropriate brevity number(s).<br>5 - None.<br>6 - Hoist.<br>7 - Stokes litter.<br>8 - Forest/jungle penetrator. | From evaluation of patient/situation | Medic and/or senior person present | Required so that the equipment can be placed on board the evacuation vehicle prior to the start of the mission. (NOTE: The semirigid litter is not part of unit TOE equipment and is not normally carried aboard the aircraft.) |
| 5 | Number of patients by type. | Report only applicable information and encrypt the appropriate amount(s) and brevity number(s). If requesting MEDEVAC for both types, insert the proword BREAK between the litter entry and ambulatory entry.<br>(#) - 9 - Litter.<br>(#) - 0 - Ambulatory (sitting). | From evaluation of patient(s) | Medic or senior person present | Required so that the appropriate number of vehicles may be dispatched to the pickup site and that they be configured to carry the patients requiring evacuation. |

Table 1-11. MEDEVAC request format (continued)

| | | | | | |
|---|---|---|---|---|---|
| 6 | Security of pickup site (wartime) | 1 - No enemy troops in area.<br>2 - Possibly enemy troops in area (approach with caution).<br>3 - Enemy troops in area (approach with caution).<br>4 - Enemy troops in area (armed escort required). | From evaluation of situation | Unit leader | Required to assist the evacuation crew in determining if assistance is required to accomplish the mission. Keep crew updated while en route. |
| 6 | Number and type of wound, injury, or illness (peacetime) | Specific information regarding patient wounds by type such as gunshot and shrapnel. Report serious bleeding, along with patient blood type, if known. | From evaluation of patient | Medic or senior person present | Required to assist evacuation personnel in determining treatment and special equipment needed. |
| 7 | Method of marking pickup site | Encrypt the appropriate brevity number(s).<br>5 - Panels.<br>6 - Pyrotechnic signal.<br>7 - Smoke signal.<br>8 - Signal person.<br>9 - Strips of fabric or parachute.<br>0 - Tree branches, pieces of wood, or stones placed together.<br>1 - Signal lamp or flashlight.<br>2 - Vehicle lights.<br>3 - Open flame. | Based on situation and availability of materials. | Unit leader | Required to assist the evacuation crew in identifying the specific location of the pickup. Note that the color of the panels and smoke should not be transmitted until the vehicle contacts the unit (just prior to its arrival). For security, the crew should identify the color and the unit should verify it. |

Table 1-11. MEDEVAC request format (continued)

| LINE | ITEM | EXPLANATION | WHERE/HOW OBTAINED | WHO NORMALLY PROVIDES | REASON |
|---|---|---|---|---|---|
| 8 | Patient nationality and status | The number of patients in each category need not be transmitted. Encrypt only the appropriate brevity number(s).<br>4 - US military.<br>5 - US civilian.<br>6 - Non-US military.<br>7 - Non-US civilian.<br>8 - EPW. | From patient | Medic or senior person present | Required to assist in planning for destination facilities and need for guards. Unit requesting support should insure that there is an English-speaking representative at the pickup site. |
| 9 | NBC contamination (wartime) | Include this line only when applicable. Encrypt the appropriate brevity number(s).<br>9 - Nuclear.<br>0 - Biological.<br>1 - Chemical. | From situation | Medic or senior person present | Required to assist in planning for the mission. (Determine which evacuation vehicle will accomplish the mission and when it will be accomplished.) |
| 9 | Terrain description (peacetime) | Include details of terrain features in and around proposed landing site. If possible, describe relationship of site to prominent terrain feature such as lake, mountain and tower. | From area survey | Personnel at site | Required to allow evacuation personnel to assess route/avenue of approach into area. Of particular importance if hoist operation is required. |

## Field Sanitation Facilities

(Refer to FM 21-10 for more details.) See Figures 1-27 for field latrines. Keep all latrines at least 100 meters away from food operation, downhill and at least 30 meters from ground water sources. Keep latrines clean and use residual insecticide to control insects. Once the latrine is full to 1 foot below surface, or is to be abandoned, remove box and spray the pit and the area within 2 feet around the pit. Fill pit with successive 3-inch layers of compacted soil. Mound the pit with at least 1 foot of dirt and spray with insecticide. Place sign on top of mound indicating type, date closed, and unit. When high water tables preclude the use of pit latrines, burn out latrines may be used. Half of a 55 gallon drum or barrel is installed under each hole in the latrine box. The drum is removed daily, fuel oil is added, and the contents are burned to a dry ash. An inch of diesel fuel is added for insect control before replacing the drum in the latrine box. Construct both hand washing facilities and shower unit (Figures 1-28 and 1-29).

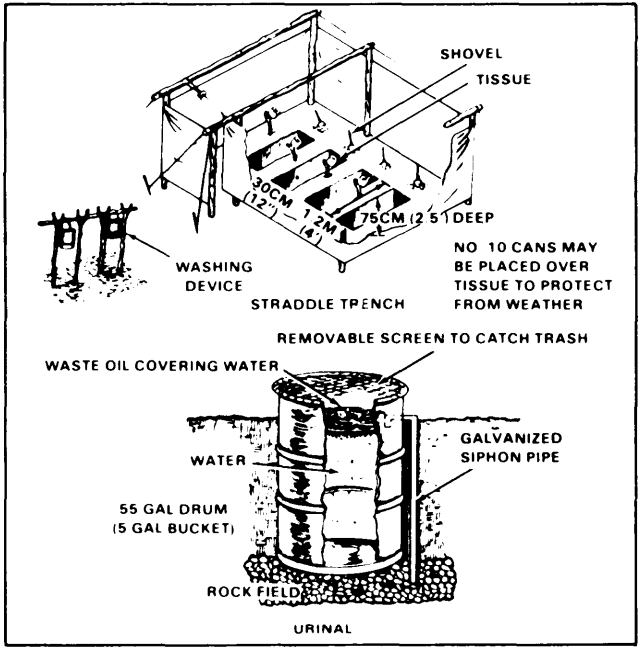



Figure 1-27. Field latrines

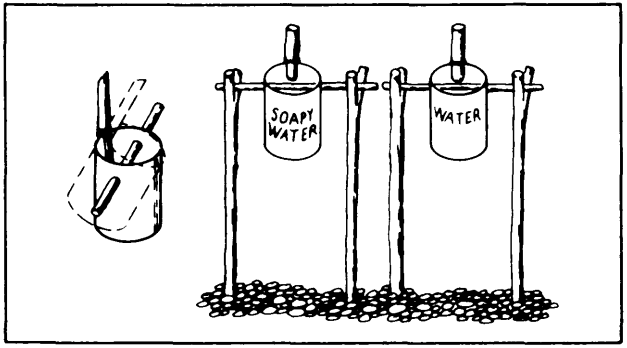



Figure 1-28. Hand-washing device, using No. 10 can

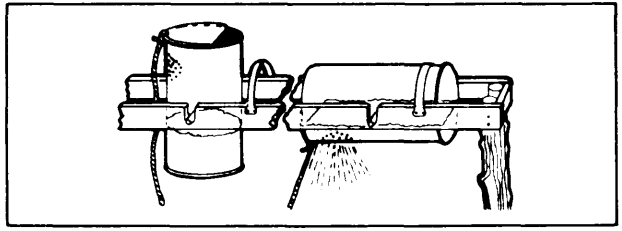


Figure 1-29. Shower unit, using metal drums

## Water Disinfection and Quantity Requirements

### Water disinfection

**Calcium hypochlorite.** The following procedure is used to purify water in a one-quart canteen with calcium hypochlorite ampules:

- Fill the canteen with the cleanest, clearest water available, leaving an all space of an inch or more below the neck of the canteen.
- Fill a canteen cup half full of water and add the calcium hypochlorite from one ampule. Stir until dissolved.
- Fill the cap of a plastic canteen half full of the solution in the cup and add it to the water in the canteen. Then place the cap on the canteen and shake it thoroughly..
- Loosen the cap slightly and invert the canteen, letting the treated water leak onto the threads around the neck of the canteen.
- Tighten the cap on the canteen and wait at least 30 minutes before using the water for any purpose.

**Iodine tablets.** Use one tablet per one quart canteen for clear water and two tablets per one quart canteen for cloudy water. Allow the water to stand for five minutes, shake well, allowing spill over to rinse canteen neck, and allow to stand another 20 minutes before using for any purpose.

**Boiling.** Bring the water to a rolling boil for 15 seconds.

### Daily water requirements

Table 1-12. Daily water requirements

| UNIT COMMANDER | CONDITIONS OF USE | GALLONS/DAY MILD/ COLD | GALLONS/DAY DESERT/ JUNGLE | REMARKS |
|---|---|---|---|---|
| Soldier | In Combat: | | | Eating and drinking (3 days). |
| | Minimum | ½-1 | 2-3[1] | When field rations used. |
| | | 2 | 3-4[1] | Drinking plus cooking |
| | Normal | 3 | 6[2] | and personal hygiene. |
| | | | | Minimum for all purposes. |
| | March | 2 | 5[2] | All purpose (does not |
| | Temporary camp | 5 | | include bathing). |
| | | | | Waterborne sewage |
| | Temporary camp | 15 | | system and bathing. |
| | Semipermanent camp | 30-80 | | |
| | Permanent camp | 60-100 | | |
| Vehicle | Level and rolling | ⅛-½ | | |
| | Mountainous | ¼-1 | | |
| Hospital | Drinking and cooking | 10/bed | | Does not include bathing. |
| | Water waterborne sewerage | 50/bed | | Includes medical personnel. |

NOTES: 1. For unacclimatized personnel or for all personnel when dry bulb reading exceed 105° in the jungle.

2. Maximum consumption factor is dependent upon work performed, solar radiation, and other environmental stresses.

## COMMUNICATION

### Tactical Communications

Tactical communication responsibilities are:

- Senior to subordinates.
- Supporting to supported.
- Reinforcing to reinforced.
- Lateral left to right if SOP or orders do not specify

### Antenna Locations

For maximum reception, locate antenna as high as possible and avoid valleys. Locate antennas away from built up areas, metal obstructions, or electrical power lines.

### Communication Equipment

See Tables 1-13 through 1-15 (pages 1-37 and 1-38).

**Table 1-13. Communication equipment - tactical radio sets**

| NOMENCLATURE | FREQUENCY RANGE MHZ | RANGE IN KILOMETERS |
|---|---|---|
| AN/PRC-25 Series | 30-75-95 | 8 |
| NOTE: AN/PRC-25 Series includes AN/VRC-53 (vehicular) and AN/GRC-125 (vehicular and man-pack) and AN/PRC-25 (man-pack). | | |
| AN/PRC-77 Series | 30-75-95 | 8 |
| NOTE: AN/PRC-77 Series includes AN/VRC-64 (vehicular) and AN/GRC-160 (vehicular and man-pack) and AN/PRC (man-pack) | | |
| AN/VRC-46 | 30-75-95 | 32 |
| AN/VRC-47 | 30-75-95 | 32 |
| AN/GRC 106 | 2 0-29 999 | 80 |
| AN/GRC-142 | 2 0-29 999 | 80 |

NOTES: 1. One each generator set, 1.5 KW DC, for operation in a static position. When AC is available a PP-2953/U (AC/DC converter) is required.
2. When used in a static operation a 1.5 KW DC generator should be used. When AC is available a PU 620 (AC/DC Converter) is required. A TSEC/KW-7 can be used for teletypewriter message security.

**Table 1-14. Communication equipment - auxiliary and wire**

| AUXILIARY EQUIPMENT | | | |
|---|---|---|---|
| NOMENCLATURE | DESCRIPTION | RANGE | REMARKS |
| AN/GRA-39 | Remoting set, used with FM radio sets | Up to 2 mi (3.2 km) | Increases flexibility of radio sets. Increases security. Radio and antenna can be exposed while operation is not. |
| RC-292<br>OE-254 | General purpose stationary ground plane antenna | | Used to extend the range of tactical FM radio sets. Increases range of radio sets to approximately twice the stated planning range of the radio set. Radiating and ground plane elements must be of the proper length for a particular operating frequency. |
| AT-964 | Long wire. End-fed directional antenna | | Used with tactical FM radio sets. Good for reducing the enemy's ability to conduct interception and jamming. Can extend the planning range of radio sets by double or more. Depending upon the antenna used to receive/transmit at the distant site. |

Table 1-14. Communication equipment - auxiliary and wire (continued)

| WIRE EQUIPMENT | | | |
|---|---|---|---|
| NOMENCLATURE | DESCRIPTION | RANGE | REMARKS |
| TA-1/PT | Sound-powered telephone in handset form | 16 km | Planning range depends upon condition of wire (WD-1/TT). No batteries are required. Incoming signal is visual and adjustable audible. Telephone weighs 2¼ lb, case ⅞ lb. |
| TA-312/PT | Tactical field telephone | 35 km | Planning range depends upon condition of wire (WD-1/TT). Batteries are required when operation is in LB position. As in local circuit to SB-22/PT. Incoming signal is adjustable audible. Has handfree operation capability. Telephone weighs approximately 9.5 lb. |
| SB-22/PT | Lightweight, manual (monocord) switchboard. Local battery (LB) operation. | | Switchboard has 12-circuit capability, and may be expanded by "stacking" additional SB-22s. Each added SB-22 increases capability by 17 circuits, since only one operator's pack is necessary. Signaling may be audible or visual, or just visual. |
| SB-993-GT | Light, portable, emergency switchboard. | | Switchboard has 6-circuit capability for local battery (LB) telephone lines, with an additional "circuit plug" for the operator's use. Incoming signal is visual only. |

Table 1-15. RC-292 antenna configuration

| Radio Set or Receiver-Transmitter | Operating Frequency (MHz) | VERTICAL | | | | | GROUND PLANE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total Number of Antenna Sections Required | Type of Sections Used | | | | Total Number of Ground Plane Sections Required | Type of Sections Used | | | |
| | | | AB-21/GR | AB-22/GR | AB-23/GR | AB-24/GR | | AB-21/GR | AB-22/GR | AB-23/GR | AB-24/GR |
| RT-246/VRC | 30 to 36.5 | 4 | 2 | 1 | 1 | 1 | 15 | 2 | 1 | 1 | 1 |
| RT-524/VRC, RT-505/PRC-25, RT-841/PRC-77 | 36.5 to 50.5 | 3 | 1 | 1 | 1 | 1 | 12 | 1 | 1 | 1 | 1 |
| | 50.5 to 75.95 | 2 | 0 | 1 | 1 | 1 | 9 | 0 | 1 | 1 | 1 |

## Expedient Antennas

To determine antenna length (meters), use the following:

Formula: $\frac{1}{4}$ wave = $\frac{234}{F}$; $\frac{1}{2}$ wave = $\frac{468}{F}$; full wave = $\frac{936}{F}$

Where: F = frequency in megahertz

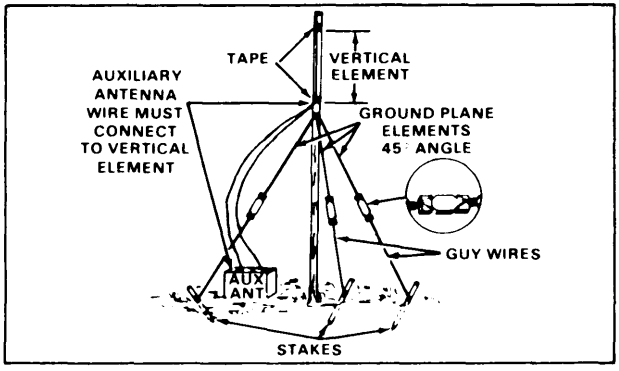



Figure 1-30. Jungle expedient antenna (FM)

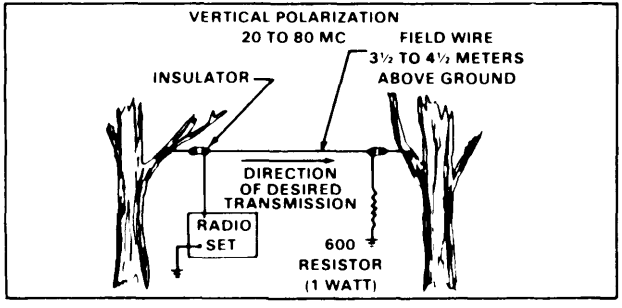



Figure 1-31. Long wire antenna (FM)

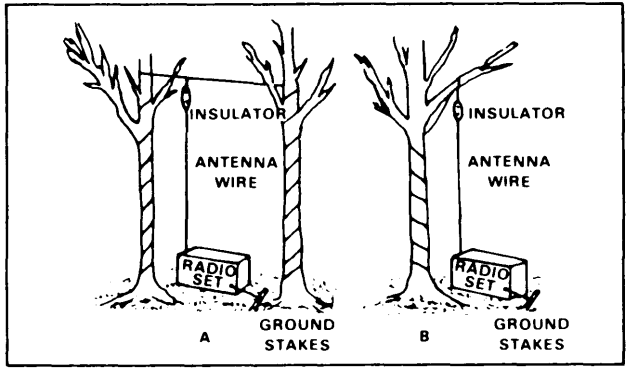



Figure 1-32. Expedient suspended vertical antennas (FM)

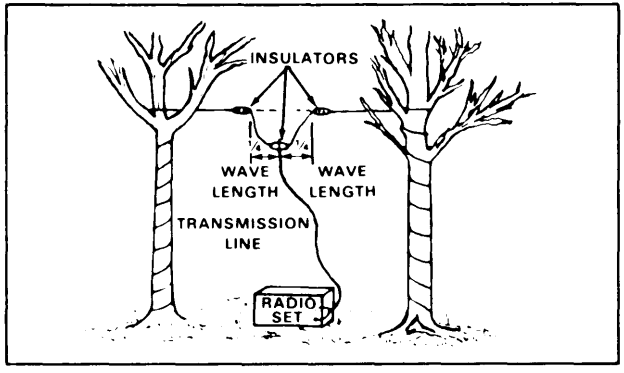



Figure 1-33. Improvised center fed half-wave antenna (AM)

## Authentication

See Figure 1-34. Authentication is mandatory in the following instances.

- Imitative deception is suspected.
- Reports of initial enemy control and amplifying reports.
- Transmission ordering or ending any radio silence.
- Plain message cancelling other message.
- When receiving a classified message uncoded, such as changing frequencies and directing movements.
- When making initial radio contact, opening and closing a net, or transmitting to station under radio listening silence.
- Whenever challenged.
- When in doubt of a station's identify.

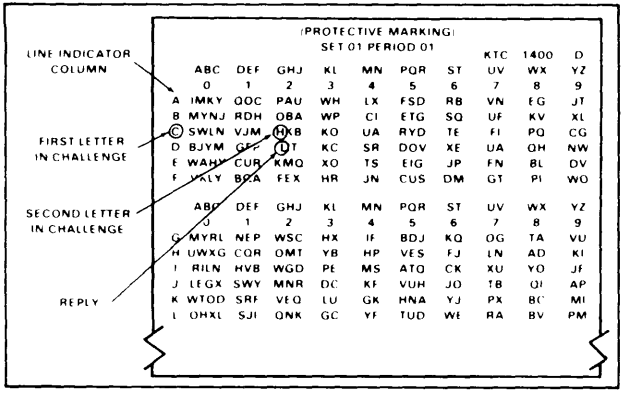



**Figure 1-34. Authentication procedures**

When challenging, select two random letters, except Z, before transmitting. Make sure you know what the reply should be. Transmit challenge," . . . AUTHENTICATE CHARLIE-HOTEL, OVER", receiving station must reply," . . . I AUTHENTICATE LIMA, OVER." If authentication is incorrect or the reply is not received promptly, transmit another challenge. If the next reply is incorrect or untimely, notify your supervisor, commander or Communications Electronics Operation (CEO).

NOTE: When challenge is from the last line, you must go to the first line for the reply.

## Standard Radio Transmission Format

CALL
MESSAGE - This proword indicates message requires recording.
PRECEDENCE - Indicates priority of call.
TIME - Followed by date-time group.
FROM - Followed by call sign.
TO - Followed by call sign of addressee.
BREAK
TEXT - May consist of plain language code or cipher groups.
BREAK
ENDING - Must include either one of two terminating prowords.
OVER or OUT, but never both in the same transmission.
EXAMPLE: ZULU FOUR CHARLIE ONE SIX - THIS IS DELTA THREE XRAY TWO NINE - MESSAGE PRIORITY - TIME 181345Z - BREAK - FIGURES 6 STRINGERS NEEDED AT MY LOCATION ASAP - BREAK - OVER.

## Visual Signals

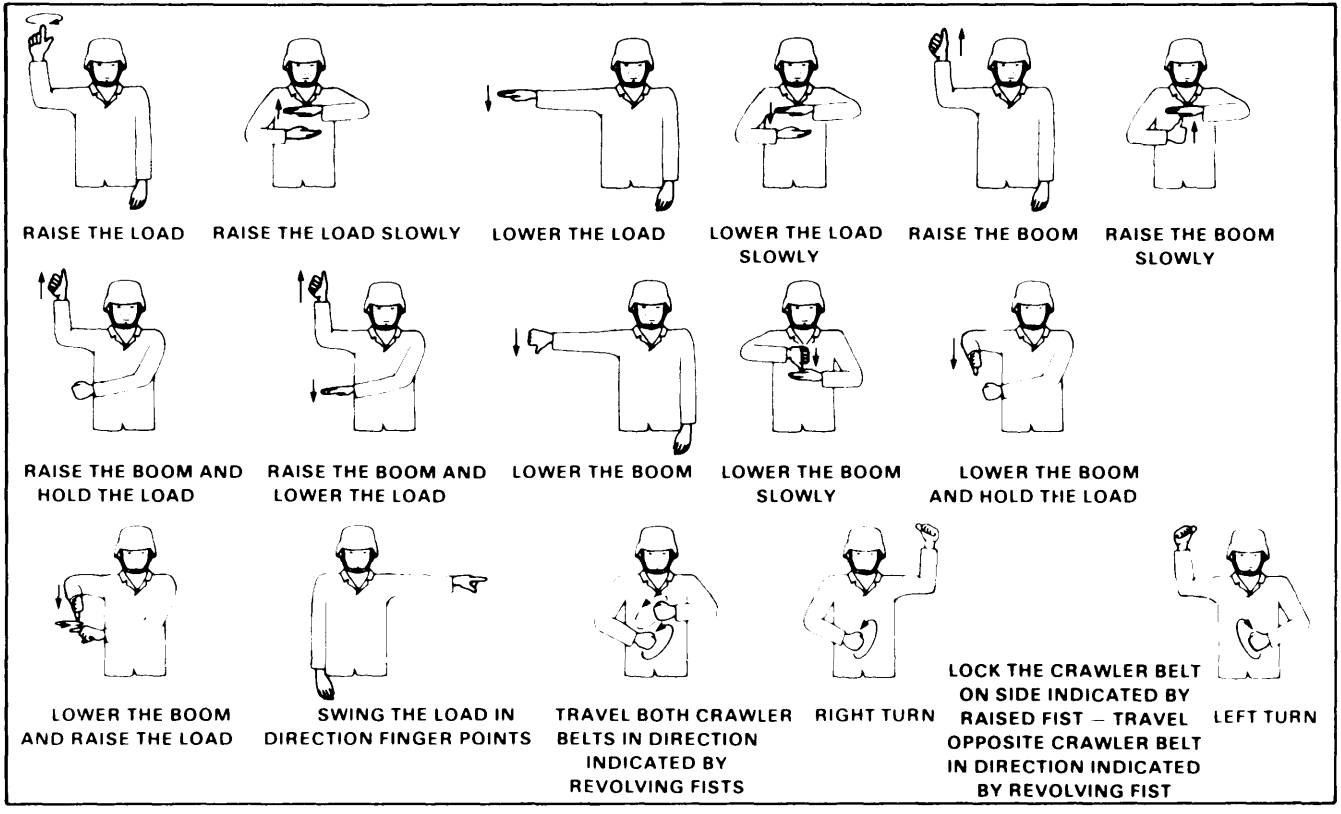



Figure 1-35. Visual signals

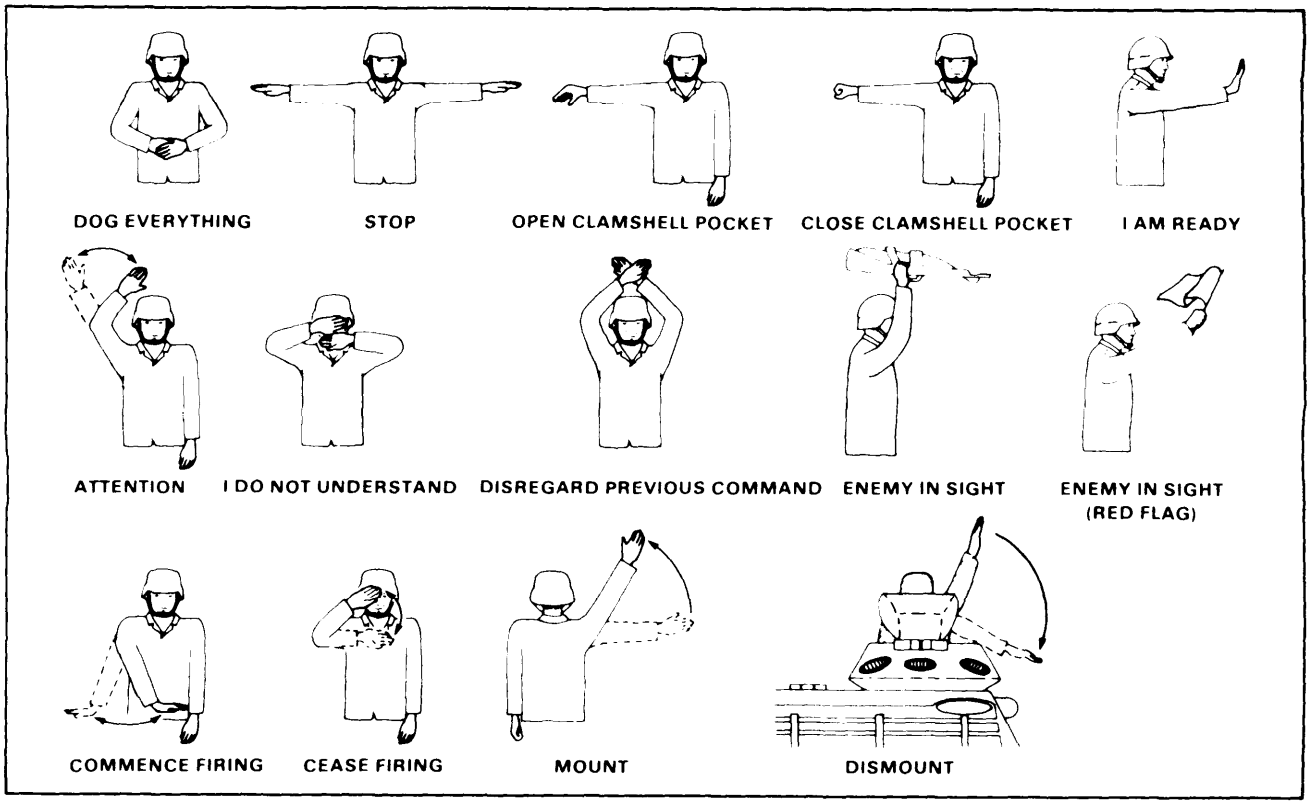



Figure 1-35. Visual signals (continued)

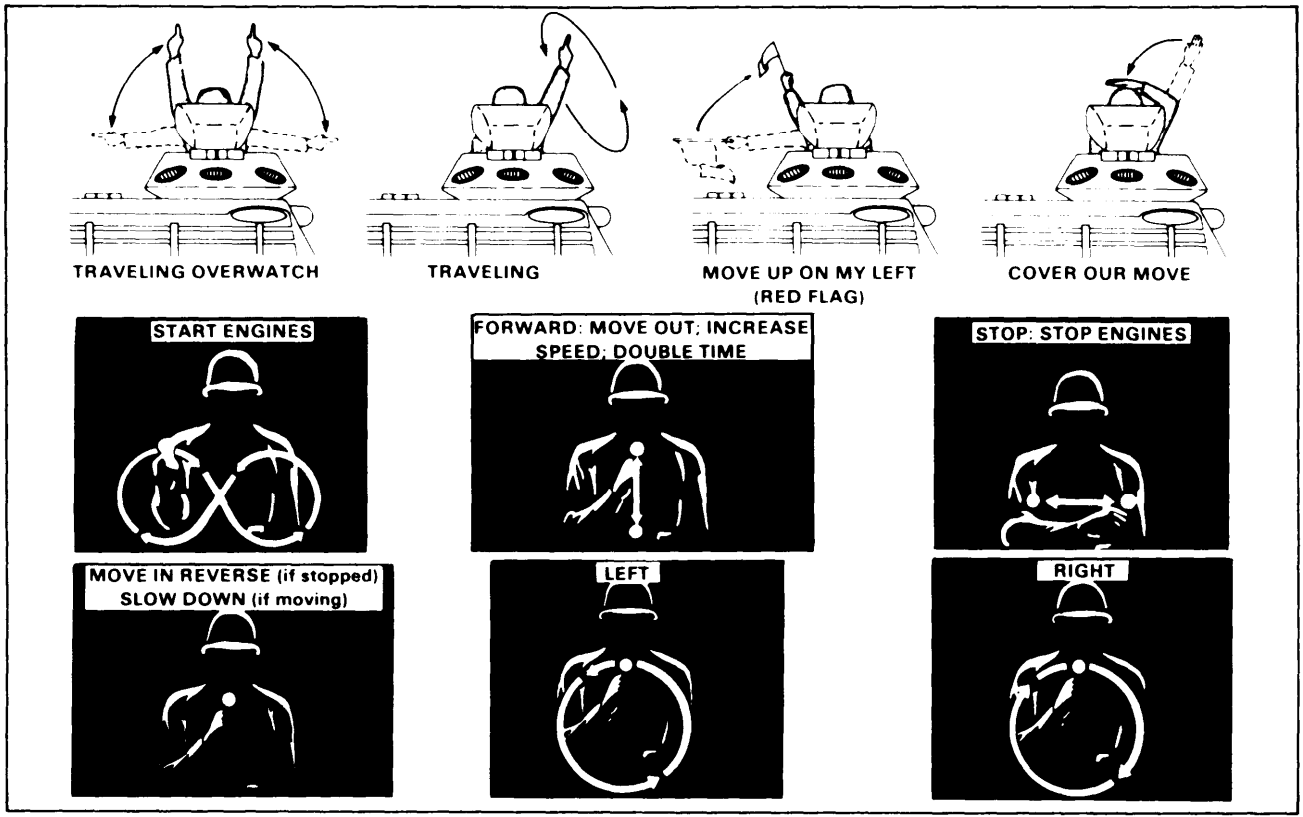



Figure 1-35. Visual signals (continued)

# Chapter 2
# Mobility

## THREAT DEFENSE

The Threat defense may be hasty or deliberate, with emphasis on mine employment All obstacles are covered by director indirect fires.

### Hasty Defense

The main obstacle employed is the Threat standard hasty minefield budding block (Figure 2-1).

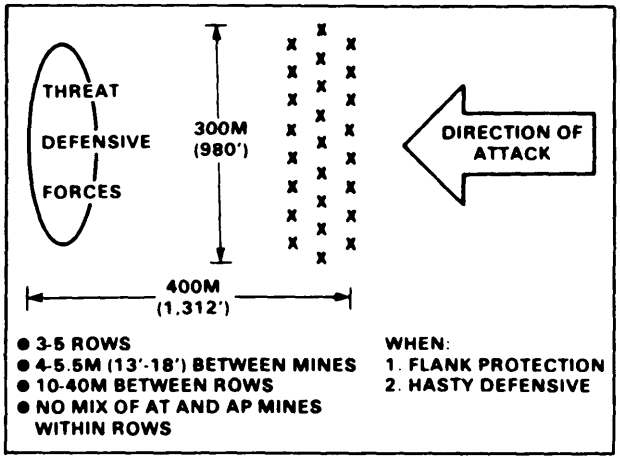



Figure 2-1. Threat hasty minefield

### Deliberate Defense

The threat defensive obstacle system normally consists of three complex obstacles. Each complex obstacle contains a minefield, normally with three rows 10 to 40 meters apart, and other types of obstacles. Mines within each row are 3 to 5 meters (10 to 16 feet) apart and may be antitank (AT) or antipersonnel (AP). See Figures 2-2 and 2.3 for representative Threat obstacle systems.

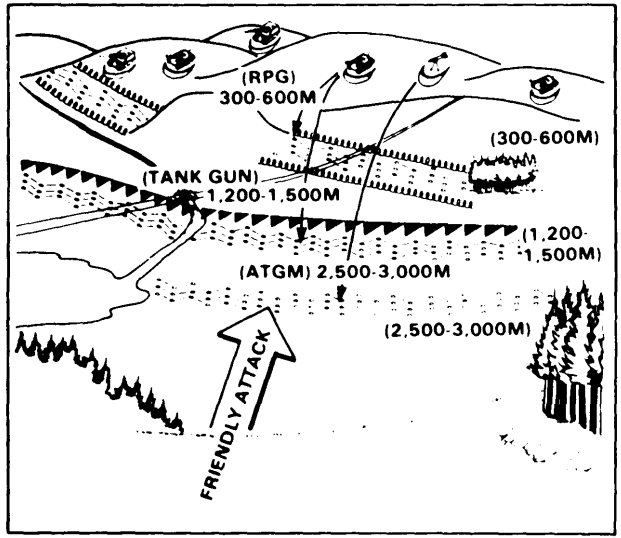



Figure 2-2. Enemy defensive positions and fully developed obstacle system



[redacted]

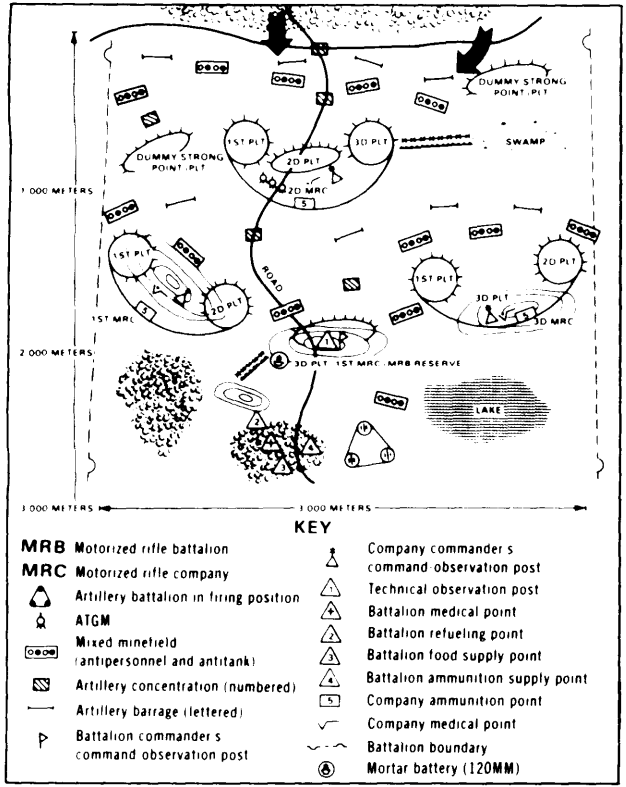



**Figure 2-3. Typical motorized rifle battalion strong point**

## Major Equipment

Equipment used to prepare the Threat defense is shown in Table 2-1.

**Table 2-1. Threat defensive engineer equipment**

| MINE LAYING EQUIPMENT | | | | | |
|---|---|---|---|---|---|
| NOMENCLATURE | TYPE | WORKING SPEED KMPH | DISTANCE BETWEEN MINES METERS (FEET) | DEPTH OF MINES CENTIMETERS (INCHES) | ALLOCATION |
| PMR 2 | Dual chute trailer | * | 4 - 5.5 (13 - 18) | Surface | — |
| PMR 3/4 | Single chute trailer | * | 4 - 5.5 (13 - 18) | 30 - 40 (12 - 16) | 12 per MRD/TD 3 per MRR/TR |
| GMZ | Tracked minelayer | 5 - 10 | 4 - 5 (13 - 16) | 30 - 40 (12 - 16) | 3 per MRD/TD |
| Mi4 Mi8 HIPC | Helicopter with chutes | — | — | Surface | 6 per MRD/TD |

* Speed based on towing vehicle

Table 2-1. Threat defensive engineer equipment (continued)

| DITCHING AND DIGGING EQUIPMENT | | | | | |
|---|---|---|---|---|---|
| NOMEN-CLATURE | TYPE | MAX DEPTH METERS (FEET) | DITCH WIDTH METERS (FEET) | WORKING SPEED (METERS/HOUR) | ALLOCATION |
| BTM/BTM 3 | Track | 1.5 (5) | .6 - 1.1 (2 - 3.5) | 265 - 1120 | 6 per MRD<br>2 per TD<br>1 per MRR |
| MDK-2M | Track | 4.4 (14.5) | 3.4 - 4 (11 - 13) | Up to 400 | 2 per MRD<br>6 per TD<br>1 per TR |
| PZM/PZM2 | Trench excavator | 1.5 (5) | .8 (2.5) | 300M³/HR | 3 per MRR/TR |
| IMR | Engineer tractor | Variable | 3.8 (12.5) | — | 2 per MRD/TD |
| BAT/M | Track dozer | Used mainly for preparation of defensive position | | 350M³/HR | 11 per MRD/TD |

## COUNTERMINE

### Detection Methods

Conduct an analysis by reviewing the terrain enemy capabilities and past performances.

**Visual**

Check for ground disturbances, posted signs, tripwires, odd features on ground, and signs of road repairs.

**Physical (probing)**

Fasten and secure all equipment to the body, use nonmetallic probe, stay close to ground and use probe gently in 1 meter semicircle search and at a 45° angle with the ground.

**Electronic mine detector**

Rotate operators at least every 20 minutes.

### Enemy Minefield Report

Table 2-2. Report of enemy minefield

| | |
|---|---|
| ALFA | Map sheet designation |
| BRAVO | Date and time of collection of information |
| CHARLIE | Type of minefield |
| DELTA | Coordinates of minefield extremities |
| ECHO | Depth of minefield |
| FOXTROT | Enemy weapons or surveillance |
| GOLF | Estimated time to breach minefield |
| HOTEL | Estimated material and equipment needed to breach minefield |
| INDIA | Routes for bypassing minefield |
| JULIET | Coordinates of lane entry |
| KILO | Coordinates of lane exit |
| LIMA | Width of lanes, in meters |
| ZULU | Other. Types of mines, new mines, booby traps |

## Breaching methods

Table 2-3 Breaching methods

**EXPLOSIVE**

| NOMENCLATURE | TYPE | MINES CLEARED | WEIGHT (LB) | LANE CLEARED WIDTH METERS (FEET) | LANE CLEARED LENGTH METERS (FEET) | ASSEMBLY TIME | EMPLOYMENT TIME IN MINUTES (SPEED) |
|---|---|---|---|---|---|---|---|
| M58A3 (MICLIC) (Note 3) | trailer mounted | AT AP | 3.100 | 8 (26) | 100 (328) | crane and crew 35 min | 4 (25 MPH) |
| M173 (projected charge demo kit) (Note 3) | towed | AT AP | 3.000 | 8 (26) | 70 (230) | crane and 2 soldiers 30 min | 10 (15 MPH) |
| M157 (Diamond Lil) | pushed by tank | AT AP | 11.000 | 8 (26) | 100 (328) | 2 squads 1 hour | 20 (8 MPH) |
| M1E1 projected charge kit | portable | AP | 63 | 6 (2) | 50 (170) | 2 soldiers 10 min | 10 |
| M1A1 (bangalore) | portable | AP | 130/kit | 6 (2) | 15 (50) | 1 squad 5 min | 5 |

**MECHANICAL**

| NOMENCLATURE | TYPE | MINES CLEARED | WIDTH METERS (FEET) | WEIGHT (LB) | PREPARATION TIME | EMPLOYMENT TIME IN MINUTES (SPEED) |
|---|---|---|---|---|---|---|
| Roller | tank mounted | AT/AP | 2 @ 1.1 (3.6) | 20.000 | crane and crew 45 min | 4 (5 MPH) |
| Plow | tank mounted (Note 1) | AT/AP | 2 @ 1.8 (6) | 12.000 | crane and crew 45 min | 4 (3 MPH) |

**MANUAL**

| | LANE CLEARED WIDTH METERS | MAN-HOURS REQUIRED PER 100 METERS | REMARKS |
|---|---|---|---|
| Location by probing | 1 (footpath) | 16 - 22 | (Note 2) |
| Removal by rope or explosives | 1 (footpath) | 38 - 44 | (Note 2) |
| Location by detector assisted by probing | 8 (one-way vehicle lane) | 27 - 33 | (Note 2) |
| Removal by rope or explosives | 8 (one-way vehicle lane) | 220 - 247 | (Note 2) |

NOTES
1. Plows issued to M1 units should be mounted prior to combat and remain permanently attached.
2. Based upon average conditions of visibility and moderate enemy activity and normal US countermeasures, such as screening of enemy observation and counterbattery fires against hostile artillery or other weapons covering the field.
3. Breaching vehicles should place one track/wheel in the line charge crater to ensure straddling the skip zone.

### Manual breaching and clearing

Use grappling hooks to clear booby traps prior to starting operation and thereafter as needed. Figure 2-4 and Table 2-4 show team composition and equipment for a breaching/clearing operation.

**Table 2-4.** Sweep team equipment

| PERSONNEL | *KEY | EQUIPMENT |
|---|---|---|
| Mine Detector Operator | 1 | Mine detector |
| Marker/Prober | 2 | Probe, mine markers, marking tape, or wire reel |
| NCOIC | 3 | Map and compass |
| Demolition Team | 4<br>5 | Safety pins, clips, smooth wires (18" long), 1-pound blocks of explosive, two nonelectric blasting caps, detonating cord, time fuze, two fuze igniters, and crimpers |
| Radio Operator | 6 | Radio |
| Relief Mine Detector Operator | 7 | Mine detector operator gear and weapon |
| Security | 8 | Weapon |

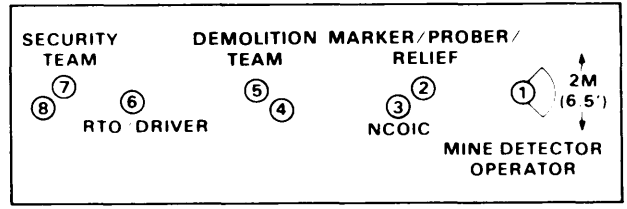



**Figure 2-4.** Sweep team composition

### Lanes and minefields clearing

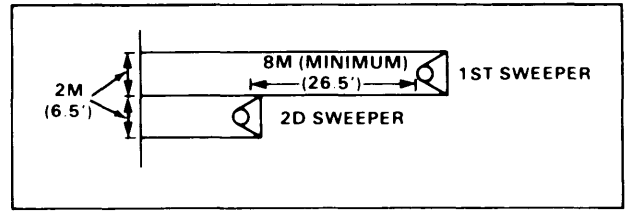



**Figure 2-5.** Breach lane clearance

Route sweep

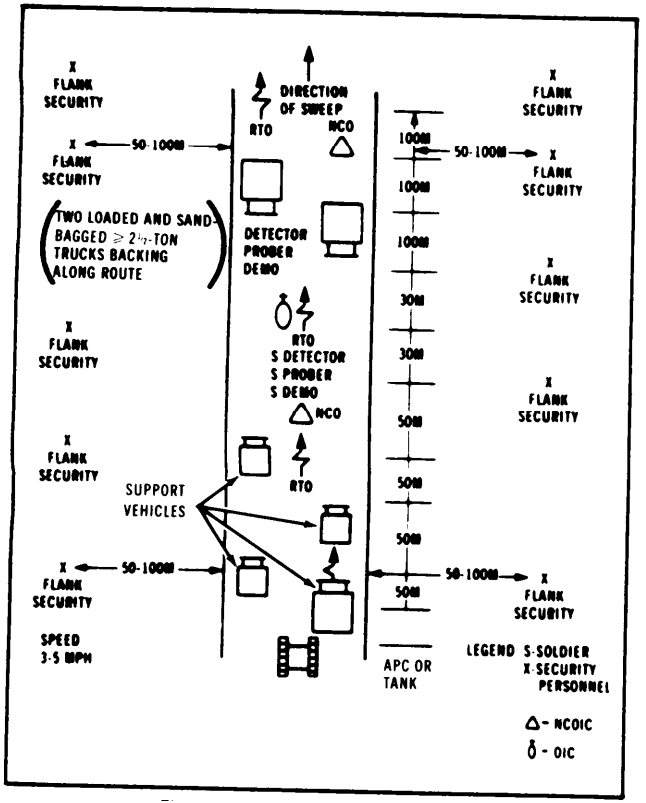



**Figure 2-6.** Route sweep formation

## Foreign Mines

UNLESS DIRECTED DIFFERENTLY, ALL FOREIGN MINES WILL BE DESTROYED IN PLACE RATHER THAN REMOVED/DISARMED.

**Table 2-5.** Foreign antitank mines

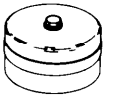
| MINE | DESCRIPTION | SKETCH |
|---|---|---|
| | SOVIET UNION | |
| TM 60 | Plastic<br>Total Wt: 11.4 kg<br>Wt of explosive: 9.9 kg<br>Fuze: Two available<br>a. nonmetallic chemical<br>b. mechanical pressure | Diameter 300MM<br> |
| TMS-B<br>TMB1<br>TMB2 | Tar impregnated cardboard, glass plug over fuze well<br>Total Wt: 6.9 kg<br>Wt of explosive: 5.0 kg<br>Fuze: MV-5K | Diameter 275MM<br>  |
| TM46 and<br>TMN46<br>TM41 | Metal<br>Total Wt: 8.7 kg<br>Wt of explosive: 5.7 kg<br>Fuze: MVM | Diameter 300MM<br> |
| TM57 | Material (Metal)<br>Total Wt: 9-12 kg<br>Fuze: Pressure or tilt rod or pneumatic | Diameter 310MM<br> |
| LMG | Rocket<br>Total Wt: 10 kg<br>Wt of explosive: 3.2 kg<br>Fuze: Pull (MUV) | |

**Table 2-5.** Foreign antitank mines (continued)

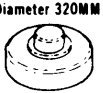
| MINE | DESCRIPTION SOVIET UNION (continued) | SKETCH |
|---|---|---|
| MZD Series | Wood, field fabricated<br>Total Wt: Variable<br>Wt of explosive: .4-4.0 kg<br>Fuze: Vibration, electric | |
| TMD B<br>TMD44 | Wood<br>Total Wt: 7.7-10 kg<br>Wt of explosive: 5-6.8 kg<br>Fuze: Pressure (MV-5) | |
| YAM 5/10<br>TMD41 | Wood<br>Total Wt: 7.7 kg<br>Wt of explosive: 5.8 kg<br>Fuze: Pull (MUV) | |
| TMK2 | Metal<br>Total Wt: 12.5 kg<br>Fuze: Tilt Rod (adjustable) | |
| | **CZECHOSLOVAKIA** | |
| PT Mi Ba<br>PT Mi Ba 53 | Plastic<br>Total Wt: 7.6 kg<br>Wt of explosive: 5.6 kg<br>Fuze: Pressure | Diameter 320MM<br>  |
| PT Mi Ba II/III | Plastic<br>Total Wt: 9.9 kg<br>Wt of explosive: 6 kg<br>Fuze: Pressure | |
| PT Mi K | Metal<br>Total Wt: 7.1 kg<br>Wt of explosive: 5 kg<br>Fuze: Pressure | |

**Table 2-5.** Foreign antitank mines (continued)

| MINE | DESCRIPTION CZECHOSLOVAKIA (continued) | SKETCH |
|---|---|---|
| PT Mi D/II/III | Wood<br>Total Wt: 9 kg +<br>Wt of Explosive: 6.2 kg | |
| | **EAST GERMANY** | |
| PM 60 | Similar to TM60 (Soviet) | |
| K1 | Plastic<br>Total Wt: 11 kg<br>Wt of explosive: 7 kg<br>Fuze: Pressure | |
| | **HUNGARY** | |
| Shape Charge Mine | Cardboard and plywood<br>Total Wt: 5.4 kg<br>Fuze: Pressure | |
| | **DENMARK** | |
| M/47-1 | Metal<br>Total Wt: 10 kg<br>Wt of explosive: 6.3 kg<br>Fuze: Pressure or anti-disturbance | |
| M/52 | Plastic<br>Total Wt: 10.7 kg<br>Wt of explosive: 8.3 kg<br>Fuze: Pressure-chemical | |

Table 2-5. Foreign antitank mines (continued)

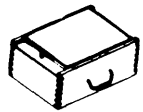
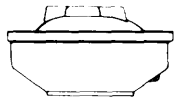
| MINE | DESCRIPTION | SKETCH |
|---|---|---|
| | **FRANCE** | |
| Model 1951<br>Nonmetallic | Has no case, cast TNT<br>Total Wt: 7 kg<br>Fuze: Pressure chemical 1950 or pressure friction 1952 | Diameter 300MM<br> |
| Model 1947<br>Nonmetallic | Bakelite case<br>Total Wt: 11 kg<br>Fuze: Pressure chemical 1950 or pressure friction 1952 | Diameter 330MM<br> |
| Model 1948 | Metal<br>Total Wt: 9 kg<br>Fuze: Main and two secondary fuze wells | Diameter 310MM<br> |
| | **ITALY** | |
| CS 42/2<br>CS 42/3 | Wood<br>Total Wt: 6.9 kg<br>Wt of explosive: 5 kg<br>Fuze: Pressure |  |
| SH-55 | Plastic<br>Total Wt: 7.3 kg<br>Fuze: Integral pneumatic pressure<br>Diameter 265MM | |
| "Saci" 54/7 | Plastic case but metal striker detectable<br>Total Wt: Two models<br>a. light — 6.2 kg<br>b. heavy — 10.2 kg<br>Fuze: Three pressure | Diameter 265MM<br>  |

Table 2-5. Foreign antitank mines (continued)

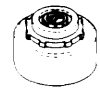
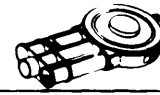
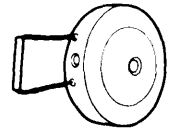
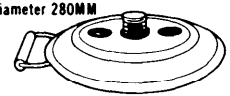
| MINE | DESCRIPTION | SKETCH |
|---|---|---|
| | **JAPAN** | |
| Type 63 | Nonmetallic<br>Total Wt: 35 lb (15 kg)<br>Wt of explosive: 24.2 lb (11 kg) |  |
| | **NETHERLANDS** | |
| MIRJAM<br>River Mine | Employs normal antitank mine, such as Model 26 (Serial 6)<br>Total Wt: 18 kg<br>Length 605MM |  |
| Model 26<br>Undetectable | Plastic reinforced with glass wool.<br>Total Wt: 9 kg<br>Fuze: Pressure-friction with shear collar control. Two secondary fuze wells for anti-lift devices | Diameter 300MM<br>  |
| Model 25 | Metal<br>Total Wt: 12.8 kg<br>Fuze: Pressure with two secondary fuze wells for anti-handling devices | Diameter 309MM<br> |
| T40 | Metal<br>Total Wt: 6 kg<br>Fuze: Pressure | Diameter 280MM<br>  |
| | **SPAIN** | |
| C.E.T.M.E. | Nonmetallic<br>Total Wt: 9.9 kg<br>Wt of explosive: 5.2 kg<br>Fuze: Chemical or mechanical | |

Table 2-5. Foreign antitank mines (continued)

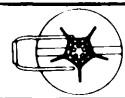
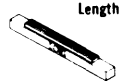
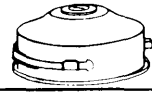
| MINE | DESCRIPTION | SKETCH |
|---|---|---|
| | **SWEDEN** | |
| Model 52 | Wood and fabrics<br>Total Wt: 8.9 kg<br>Wt of explosive: 7.4 kg<br>Fuze: Pressure |  |
| M1 101 | Nonmetallic<br>Total Wt: 12.4 kg<br>Wt of explosive: 11 kg<br>Fuze: No data | |
| Model 41-47 and 47 | Metallic<br>Wt of explosive: 5 kg<br>Fuze: Pressure | |
| | **UNITED KINGDOM** | |
| L9A1 | Nonmetallic<br>Total Wt: 11 kg | Length 1.2M<br>  |
| MK7 | Metallic<br>Total Wt: 14.7 kg<br>Wt of explosive: 8.8 kg<br>Fuze: Pressure | Diameter 330MM<br>  |
| L3A1 | Plastic w/removable detector ring<br>Total Wt: 7.7 kg | Diameter 266MM<br> |
| L14A1 | Off-road<br>Total Wt: 13 kg<br>Max Range: 80m<br>Fuze: Actuated by break wire across kill zone | Height 330MM<br>Length 260MM<br> |

Table 2-5. Foreign antitank mines (continued)

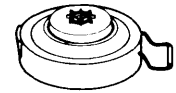
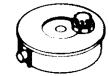
| MINE | DESCRIPTION | SKETCH |
|---|---|---|
| | **WEST GERMANY** | |
| DM 11 | Plastic<br>Total Wt: 7.4 kg<br>Wt of explosive: 7 kg<br>Fuze: DM 46 pressure | Diameter 300MM<br>  |
| DM 39 | Plastic<br>Total Wt: 0.50 kg<br>Wt of explosive: 0.31 kg<br>Fuze: Antilift device with pressure release fuze | Diameter 118MM<br>  |
| DM 49 | Plastic<br>Total Wt: 0.50 kg<br>Wt of explosive: 0.20 kg<br>Fuze: Antilift device with pressure release fuze | 90MM<br> |

Table 2-6. Foreign antipersonnel mines

| MINE | DESCRIPTION | SKETCH |
|---|---|---|
| | **SOVIET UNION** | |
| POM 2-2M | Cast iron case<br>Total Wt: 1.7 kg<br>Wt of explosive: 0.75 kg<br>Fuze: MUV-2 | Diameter 60MM<br> |
| OZM-3<br>OZM-4 | Steel<br>Total Wt: 4.54 kg<br>Wt of explosive: 0.75 kg<br>Fuze: MUV or MUV-2 | Diameter 77MM<br> |

Table 2-6. Foreign antipersonnel mines (continued)

| MINE | DESCRIPTION SOVIET UNION (continued) | SKETCH |
|---|---|---|
| MON 100 and MON 200 | Metal<br>Total Wt:<br>MON 100 5 kg<br>MON 200 25 kg<br>Wt of explosive:<br>MON 100 2 kg<br>MON 200 12 kg<br>Fuze: Electric command or tripwire | Diameter:<br>MON 100 220MM<br>MON 200 520MM |
| PMN | Phenolic body with rubber cover<br>Total Wt: 0.60 kg<br>Wt of explosive: 0.216 kg<br>Fuze: Integral with mine | Diameter 100MM |
| PMD6<br>PMD7 | Wood<br>Total Wt: 398 gm<br>Wt of explosive: 200 gm<br>Fuze: Pull (MUV) | |
| | CZECHOSLOVAKIA | |
| PP Mi S6 | Concrete case<br>Total Wt: 2.1 kg<br>Wt of explosive: 0.075 kg<br>Fuze: R01 pull or<br>R08 pressure | Diameter 75MM |
| PP Mi Sr | Steel<br>Total Wt: 3.25 kg<br>Wt of explosive: 0.325 kg<br>Fuze: R01 pull or<br>R08 pressure | Diameter 100MM |

Table 2-6. Foreign antipersonnel mines (continued)

| MINE | DESCRIPTION CZECHOSLOVAKIA (continued) | SKETCH |
|---|---|---|
| PP Mi ST-46 | Cast iron case | |
| | HUNGARY | |
| Ramp Mine | Metal<br>Total Wt: 1.4 kg<br>Wt of explosive: .8 kg<br>Fuze: Pull | |
| M62 | Plastic<br>Total Wt: 386 gm<br>Wt of explosive: 74 gm<br>Fuze: Pull (MUV) | |
| Bounding | Metal case<br>Total Wt: 3.6 kg<br>Wt of explosive: .8 kg<br>Fuze: Pull | |
| | EAST GERMANY | |
| K-2 | Plastic w/metal<br>Total Wt: 4 kg<br>Wt of explosive: 3 kg<br>Fuze: Pressure | |
| | FRANCE | |
| Model 1948 | Nonmetallic<br>Total Wt: .56 kg<br>Wt of explosive: 170 gm | |

Table 2-6. Foreign antipersonnel mines (continued)

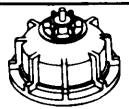
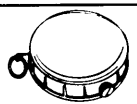
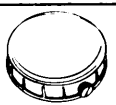
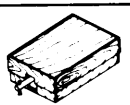
| MINE | DESCRIPTION FRANCE (continued) | SKETCH |
|---|---|---|
| Model 1951 Nonmetallic | Plastic<br>Total Wt: 0.85 kg<br>Fuze: Integral pressure friction<br>Diameter 70MM |  |
| Model 1951/55 Bounding | Metal<br>Total Wt: 4.5 kg<br>Fuze: Model 1952 tilt rod<br>Diameter 110MM | |
| DV 56 Nonmetallic Model 1956 | Plastic<br>Total Wt: 0.16 kg<br>Fuze: Friction pressure<br>Diameter 70MM | |
| | ITALY | |
| Minelba Type A | Metal<br>Total Wt: 0.17 kg<br>Fuze: Integral pneumatic<br>Diameter 110MM |  |
| Minelba Type B | Similar in outer appearance to Type A but is made of plastic and has no safety pin hole, and no safety device<br>Diameter 110MM |  |
| AUS 50/5 | Plastic<br>Total Wt: 1.4 kg<br>Fuze: Pressure/pull<br>Diameter 125MM | |
| Type R | Wood<br>Total Wt: .5 kg<br>Fuze: Pressure/pull |  |

Table 2-6. Foreign antipersonnel mines (continued)

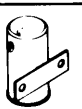
| MINE | DESCRIPTION ITALY (continued) | SKETCH |
|---|---|---|
| Valmara | Metallic<br>Total Wt: 3.2 kg<br>Wt of explosive: .54 kg<br>Fuze: Pressure/pull | |
| | NETHERLANDS | |
| Model 22 Nonmetallic | Plastic<br>Total Wt: 0.85 kg<br>Fuze: Integral pressure friction with shear collar control<br>Diameter 71MM | |
| Model 15 | Plastic<br>Total Wt: 0.6 kg<br>Fuze: Pressure igniter<br>Length 114MM<br>Width 100MM | |
| | SPAIN | |
| FAMD | Plastic<br>Total Wt: 97 gm<br>Wt of explosive: 48 gm<br>Fuze: Pressure | |
| | SWEDEN | |
| M49<br>M49B | Cardboard<br>Total Wt: .23 kg<br>Fuze: Pressure | |
| M48 | Fragmentation<br>Total Wt: 2.9 kg<br>Wt of explosive: .23 kg<br>Fuze: Pull |  |

Table 2-6. Foreign antipersonnel mines (continued)

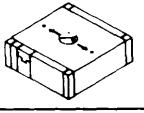
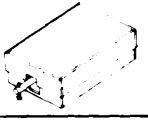
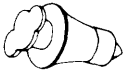
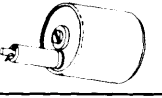
| MINE | DESCRIPTION | SKETCH |
|---|---|---|
| | **SWEDEN (continued)** | |
| Model 43<br>Model 43(T) | Concrete<br>Total Wt: 5.8 kg<br>Wt of explosive: .6 kg<br>Fuze: Pull | |
| M/43 T | Cardboard<br>Total Wt: .23 kg<br>Wt of explosive: .14 kg<br>Fuze: Pressure |  |
| M41 | Wood<br>Total Wt: 0.35 kg<br>Wt of explosive: 0.12 kg<br>Fuze: Pressure pin withdrawal |  |
| | **SWITZERLAND** | |
| M3 | Nonmetallic<br>Total Wt: 93 gm<br>Wt of explosive: 68 gm | |
| P59 | Plastic<br>Wt of explosive: 60 gm<br>Fuze: None | |

Table 2-6. Foreign antipersonnel mines (continued)

| MINE | DESCRIPTION | SKETCH |
|---|---|---|
| | **UNITED KINGDOM** | |
| Mine Antipersonnel No. 6 (i) | Plastic mine with metal detector ring | Length 203MM<br> |
| Mine Antipersonnel No. 7 (Dingbat) | Small metal mine, actuated by a load of 3.20 kg<br>Total Wt: 0.11 kg | Diameter 63MM<br> |
| Mine Antipersonnel Nonmetallic C3 (Elsie) | Small plastic mine with removable detector ring<br>Total Wt: 0.08 kg | Length 76MM<br>  |
| | **WEST GERMANY** | |
| DM 11 | Plastic<br>Total Wt: 200 gm<br>Wt of explosive: 114 gm | Diameter 80MM<br> |
| DM 31 | Steel<br>Total Wt: 4 kg<br>Wt of explosive: 0.53 kg<br>Fuze: DM56 | Diameter 102MM<br>  |

## OBSTACLE BREACHING

### Obstacle Report

| | |
|---|---|
| ALFA | Map sheet(s). |
| BRAVO | Date-time group of observation. |
| CHARLIE | Location (grid reference). |
| DELTA | Type of obstacle. |
| ECHO | Enemy weapons having coverage on the obstacle, if any. |
| FOXTROT | Any other information which could impact on breaching or bypass, for example, terrain restricts bypass, work required (in personnel-hours) to breach obstacle. |

**Figure 2-7.** Obstacle report

### Obstacle Crossing Capabilities

See Table 2- 7 for selected US and foreign equipment obstacle crossing capabilities.

**Table 2-7.** Equipment obstacle crossing capabilities

| COUNTRY/ VEHICLE | MIL CLASS | FORDING METERS (FEET) | HEIGHT TO CLEAR METERS (FEET) | WIDTH TO CLEAR METERS (FEET) | MAX GAP TRAVERSE METERS (FEET) | GROUND CLEARANCE METERS (INCHES) | MAX STEP METERS (INCHES) | MAX TILT (%) | MAX GRADIENT (%) | MAX STRATTLE METERS (FEET) |
|---|---|---|---|---|---|---|---|---|---|---|
| US/M728 (CEV) | 57 | 1.22 (4.0) | 3.19 (10.5) | 3.59 (11.8) | 2.54 (8.3) | .41 (16) | .75 (30) | 30 | 60 | 2.21 (7.3) |
| US/M113 | 13 | Unlimited | 2.13 (7.0) | 2.68 (8.8) | 1.60 (5.2) | .29 (11) | .64 (25) | 30 | 60 | 1.78 (5.8) |
| US/M-2 & M-3 | 24 | Unlimited | 2.92 (9.6) | 3.04 (10.0) | 2.54 (8.3) | .45 (18) | .91 (36) | 40 | 60 | 1.87 (6.1) |
| US/M60 | 54 | 1.22 (4.0) | 3.26 (10.7) | 3.63 (12.0) | 2.66 (8.7) | .41 (16) | .91 (36) | 30 | 60 | 2.21 (7.3) |
| US/M48A5 | 53 | 1.22 (4.0) | 3.12 (10.2) | 3.63 (12.0) | 2.59 (8.5) | .41 (16) | .91 (36) | 30 | 60 | 2.21 (7.3) |
| US/MI | 60 | 1.22 (4.0) | 2.89 (9.5) | 3.60 (11.8) | 2.74 (9.0) | .48 (19) | 1.24 (49) | 40 | 60 | 2.14 (7.0) |
| FRG/LEOPARD2 | 46 | 2.25 (7.4) | 2.93 (9.6) | 3.71 (12.2) | 3.00 (10.0) | .48 (19) | 1.15 (45) | 30 | 60 | 2.15 (7.1) |
| UK/Centurian | 60 | 1.20 (3.9) | 2.96 (9.7) | 3.40 (11.2) | 3.35 (11.0) | .51 (20) | .90 (35) | 30 | 60 | 2.19 (7.2) |
| UK/Chieftian | 45 | 1.07 (3.5) | 2.90 (9.5) | 3.66 (12.0) | 3.15 (10.3) | .51 (20) | .91 (36) | 30 | 60 | 2.44 (8.0) |
| FR/AMX30 | 38 | 2.00 (6.6) | 2.86 (9.4) | 3.10 (10.2) | 2.90 (9.5) | .45 (18) | .93 (37) | 30 | 60 | 1.96 (6.4) |

## Nonexplosive Obstacle Breaching Equipment

Table 2-8. Nonexplosive obstacle breaching equipment

| NOMENCLATURE | LOAD CLASS | HEIGHT METERS (FEET) | WIDTH METERS (FEET) | SPEED KMPH (MPH) | ARMAMENT | MOBILITY EMPLOYMENT |
|---|---|---|---|---|---|---|
| M728 (CEV) | 57 | 3.25 (10.7) | 3.7 (12) | 48 (30) | 165MM<br>M85 (.50 cal)<br>M240 (7.62M) | Destroy bunkers and log obstacles<br>Breach tank ditch and craters<br>Remove road blocks, trees, and rubbles |
| M9 (ACE) | 18 | 2.3 (7.5) | 3.2 (10.5) | 48 (30+) | None | Fill craters and ditches<br>Remove road blocks, trees, and rubbles<br>Prepare river and ford access<br>Prepare and maintain routes |
| D7F (Dozer) | 28 | 2.4 (7.9) | 3.48 (11.4) | 10 (6) | None | Cut tactical routes<br>Fill craters and ditches<br>Remove rubbles and trees |
| Loader (2 ) | 20 | 3.7 (12) | 2.6 (8.5) | — | None | Fill craters and ditches<br>Wire obstacle removal |
| AVLB w/ bridge<br>w/o bridge | 57<br>37 | 5 (16.4) | 4 (13.1) | 48 (30) | None | Bridge gaps 18 meters or less<br>Bridge gaps 15 meters or less for Class 70 |

## Breaching Procedures

See Table 2-9 and Figures 2-8 through 2-12 (pages 2-16 and 2-17) for obstacle breaching procedures

Table 2-9 Obstacle breaching

| LEGEND | OBSTACLE ENCOUNTERED | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DESIRABILITY OF EMPLOYMENT<br>SCALE:<br>1 = Most desirable<br>10 = Least desirable | MINEFIELD — 4M LANE | | WIRE | AT DITCH/ROAD CRATER | STEEL OBSTRACTION | CONCRETE OBSTRACTION | WALLS | ABATIS | LOG OBSTRACTION | BUNKER | RUBBLE |
| RESOURCES AVAILABLE | SURFACE | BURIED | | | | | | | | | |
| Grapnel Hook | 8 | 7 | 7 | | 3 | | | 5 | 5 | | |
| Pioneer Kit | | | 8 | 6 | | | | 6 | 6 | | |
| Chain Saw | | | | | | | | 4 | 4 | | |
| Probe | * | * | | | | | | | | | |
| Mine Detector/Probe | * | * | | | | | | | | | |
| Blade (Dozer, CEV, ACE) | 5 | | 4 | 1 | 2 | 3 | | 2 | 2 | | 1 |
| CEV 165MM | | | | | | 1 | 1 | 1 | 1 | 1 | |
| AVLB | | | | 2 | | | 3 | | | | |
| Roller | 4 | 4 | | | | | | | | | |
| Mine (Plow) Blade | 3 | 3 | 3 | | | | | | | | |
| Bangalore | | | 6 | | | | | | | | |
| Explosives | 7 | 6 | 9 | 5 | 1 | 2 | 2 | 3 | 3 | 3 | 2 |
| M173 | 2 | 2 | 2 | | | | | | | | |
| M157 | 6 | 5 | 5 | | | | | | | | |
| MICLIC | 1 | 1 | 1 | | | | | | | | |
| Direct Fire | | | | | | | | | | 2 | |
| Soft Material | | | 10 | | | | | | | | |
| Pipe | | | | 3 | | | | | | | |
| Lumber | | | | 4 | | | 4 | | | | |

*Probe and/or mine detector/probe combination are used in conjunction with the grapnel hook for explosive minefield breaching.

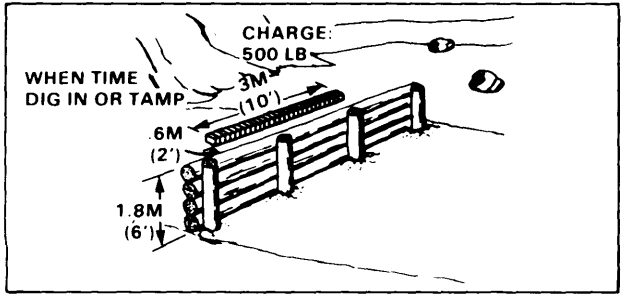



**Figure 2-8.** Backfilled log wall breaching

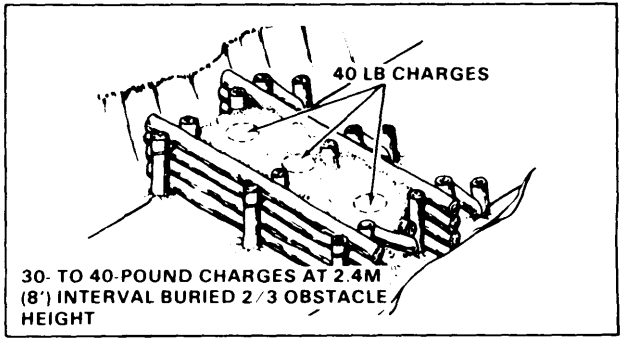



**Figure 2-9.** Log crib breaching

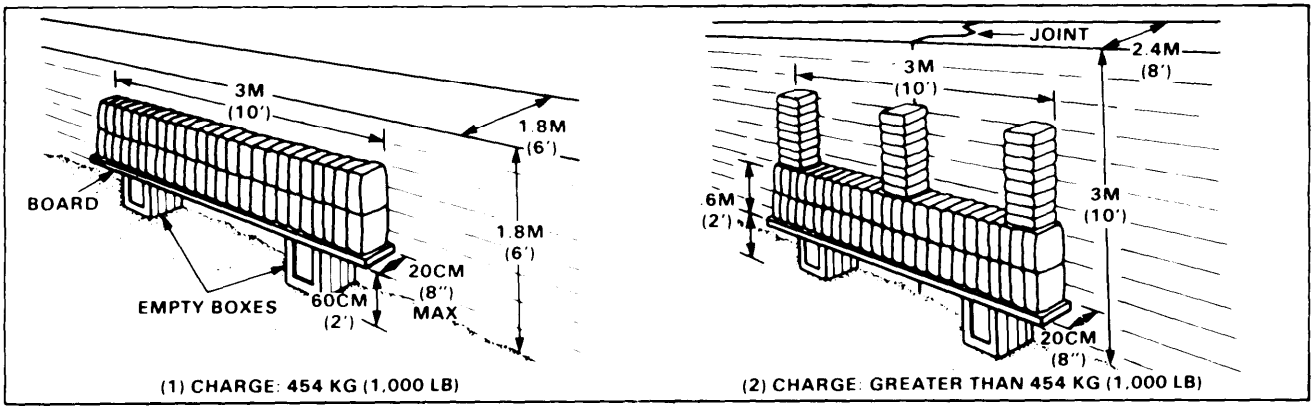



**Figure 2-10.** Placement of charges for a wall 6-feet thick (1) and for a wall over 6-feet thick (2)

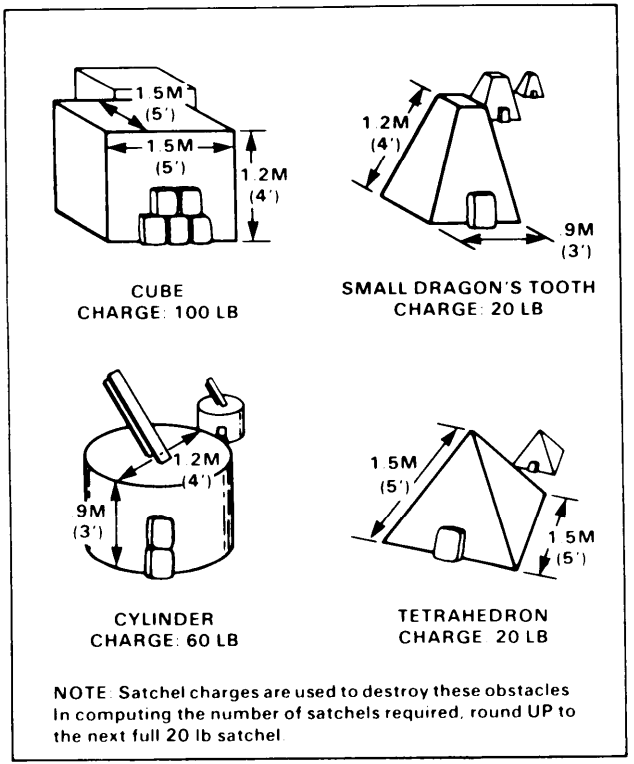



**Figure 2-11.** Explosive packs needed to destroy typical small concrete obstacles

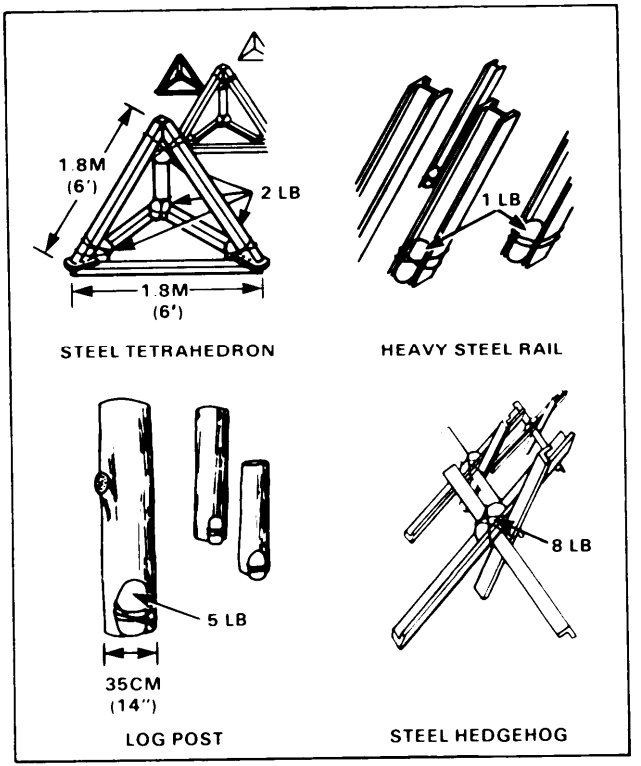



**Figure 2-12.** Placement of charges for destruction of steel and log obstacles

## COMBAT ROADS AND TRAILS

Typical Combat Roads and Trails Process and Characteristics See Figures 2-13 and 2-14.

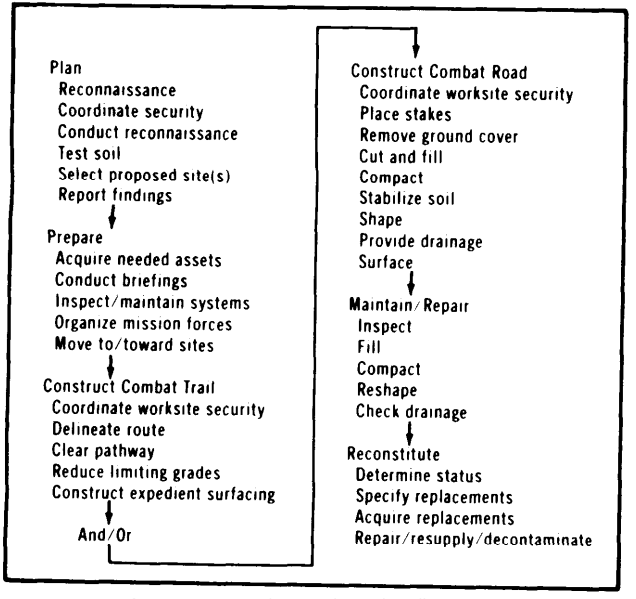



**Figure 2-13.** Combat roads and trails process

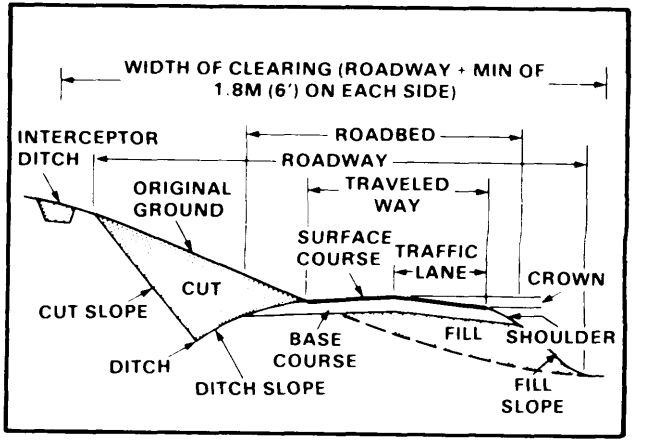



**Figure 2-14.** Typical cross-section illustrating road nomenclature

### Expedient Surfaces Over Mud

**Chespaling mats**

Chespaling mats are made by placing small saplings 6½ feet long and about 1½ inches in diameter side by side (Figure 2-15). Wire the saplings together with chicken wire mesh or strands of heavy smooth wire. A chespaling road is constructed by laying mats lengthwise with a 1-foot side overlap at the junction of the mats. The resulting surface is 12 feet wide. Unless mats are laid on wet ground, this type of road requires periodic wetting down to retain its springiness and to prevent splitting. Chespaling mats also require extensive maintenance.

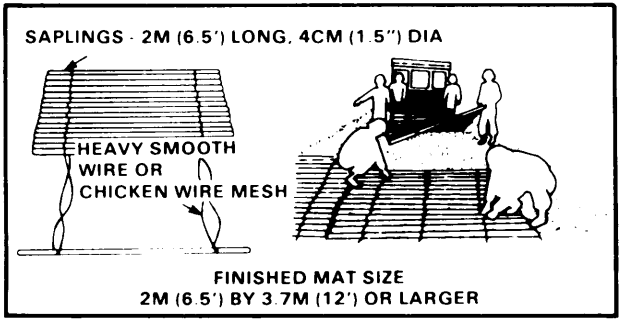



**Figure 2-15.** Chespaling surface road construction

**Corduroy**

See Figures 2-16 and 2-17 (page 2-20).

- Standard corduroy. Logs 15 to 20 centimeters (6 to 8 inches) in diameter and about 4 meters (13 feet) long are placed adjacent to each other (butt to tip). Curbs are made by placing 6-inch-diameter logs along the edges of the roadway (draft-pinned in place). Pickets about 4 feet long are driven into the ground at regular intervals along the outside edge of the road to hold the road in place. To give this surface greater smoothness, the chinks between logs should be filled with brush, rubble, and twigs; then the whole surface is covered with a layer of gravel or dirt. Side ditches and culverts are constructed as for normal roads
- Corduroy with stringer. The corduroy decking is securely pinned to stringers and then the surface is prepared as standard corduroy.
- Heavy corduroy. Heavy corduroy involves the use of sleepers, heavy logs 25 to 30 centimeters (10 to 12 inches) in diameter and long enough to cover the entire road, placed at right angles to the centerline on 1.2 meter (4-foot) centers.
- Fascine corduroy. Use fascine instead of logs for stringers.

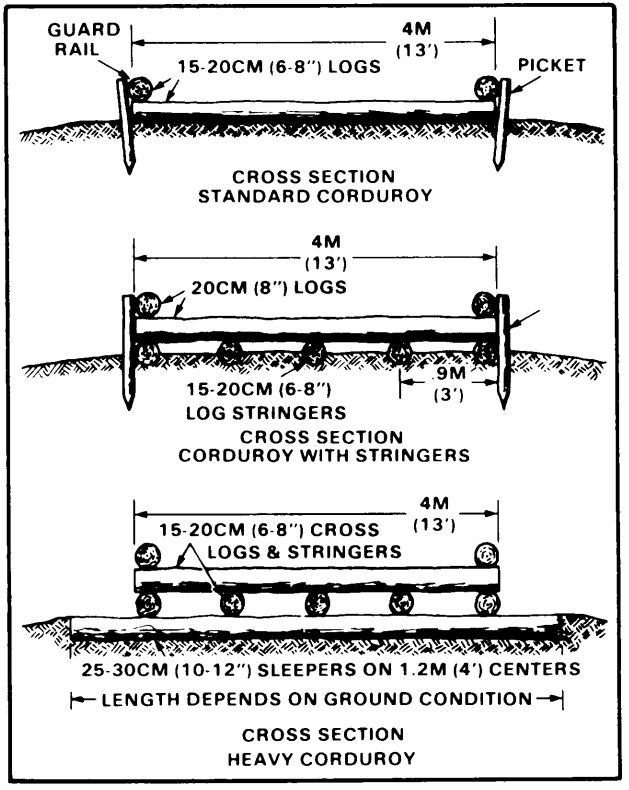



**Figure 2-16.** Corduroy road surfaces

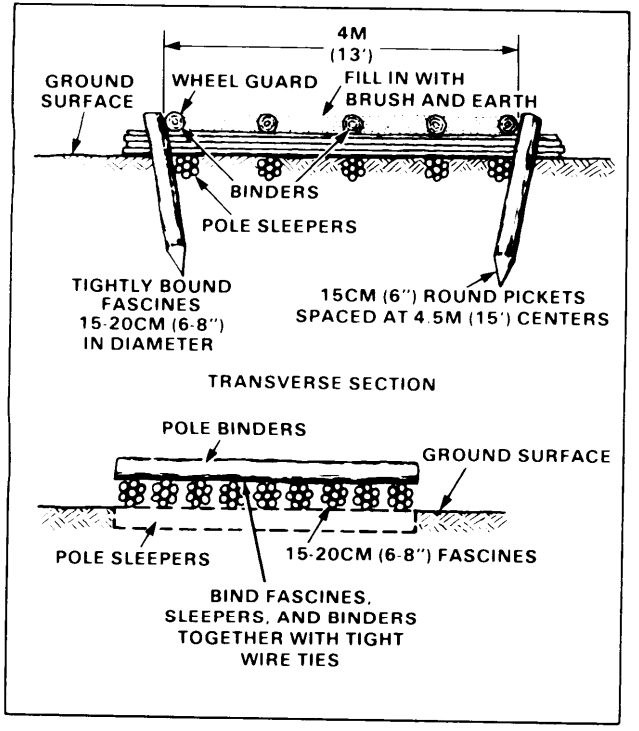



**Figure 2-17.** Fascine corduroy

**Tread roads**

Tread roads are made by preparing two narrow parallel treadways of select material using anything from palm leaves to 4-inch planks. The most common tread road is the plank tread road (Figure 2-18).

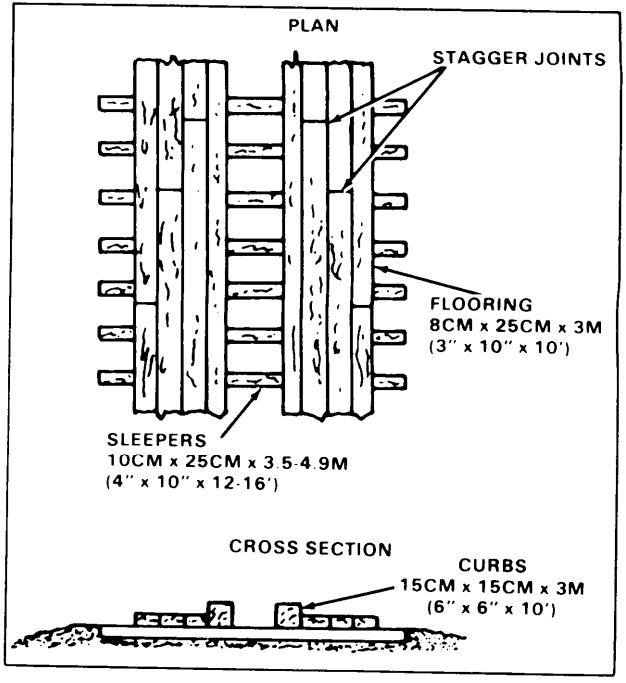



**Figure 2-18.** Plank tread road

**Army and Sommerfeld tracks**

See Figures 2-19 and 2-20 for details.

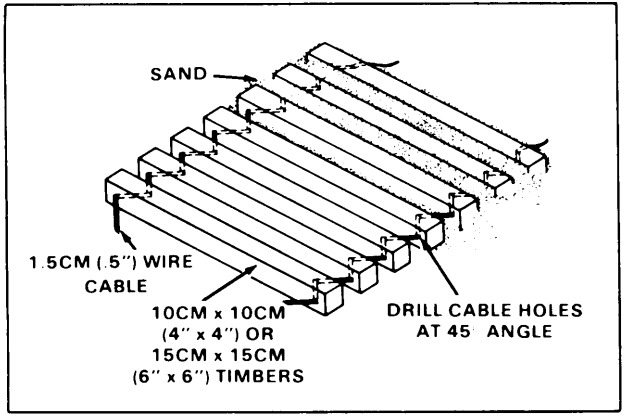



**Figure 2-19.** Army track

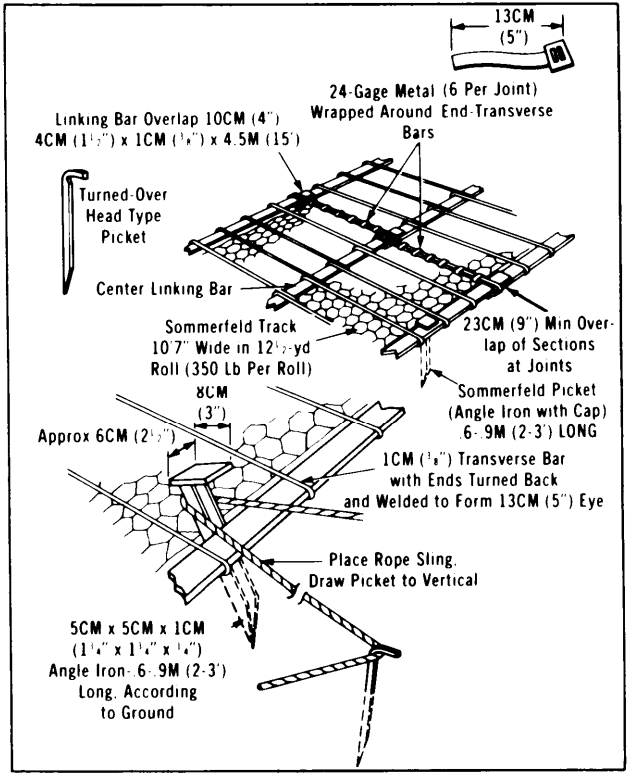



**Figure 2-20.** Component parts of Sommerfeld track

**Other types of surfaces**

Surfaces can be constructed from rubble, bricks, concrete blocks, loose aggregate or gravel, and airfield matting (Figure 2-21).

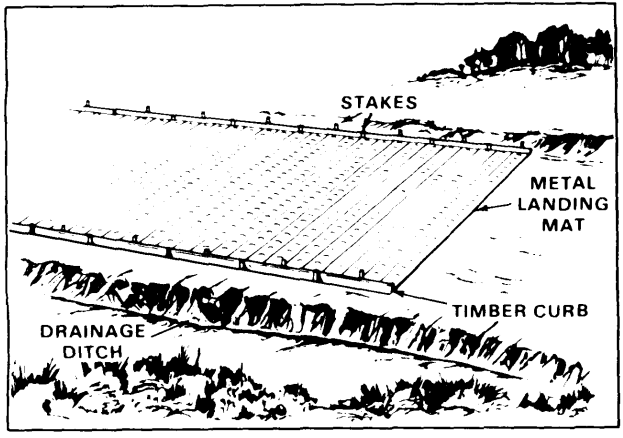



**Figure 2-21.** Other expedient surfaces

## Expedient Surfaces Over Sand

**Wire mesh**

Chicken wire, expanded metal lath, or chain-link wire mesh (cyclone fence) may be used for expedient surfaces over sand. The addition of a layer of burlap or similar material underneath the wire mesh helps to confine the sand. The edges of the wire mesh road must be picketed at .9 to 1.2 meters(3 to 4 feet) intervals. Diagonal wires crossing the centerline at 45° angles and securely attached to buried pickets fortify the lighter meshes. The more layers used the more durable the road will become (Figure 2-22).

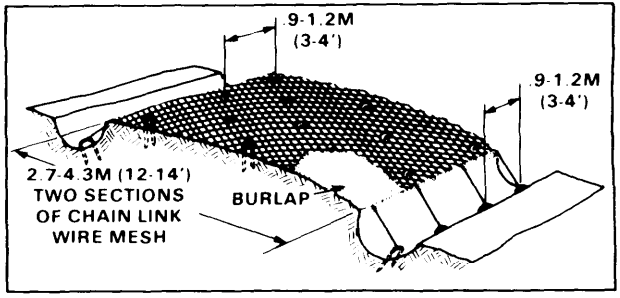



**Figure 2-22.** Construction details for a chain-link wire mesh road

**Sand grid**

See Figure 2-23 for a sand grid. Each grid section expands to cover an area 2.4 meters x 6 meters x 20 centimeters deep (8 feet x 20 feet x 8 inches). Use pickets or place sand on the corners and sides to maintain grid in place. A bucket loader may be used to fill in the grids. Use hand shovels to completely fill each grid. A full grid section will hold the weight of a bucket loader. This surface may be compacted using a rubber-tire or steel-wheel roller. A sand asphalt surface of about one gallon of RC-250 asphalt per square yard may be applied.

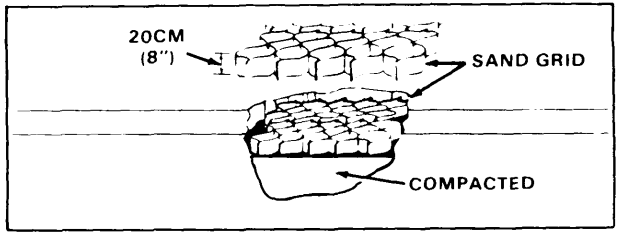



**Figure 2-23.** Sand grid

**Crater Repair**

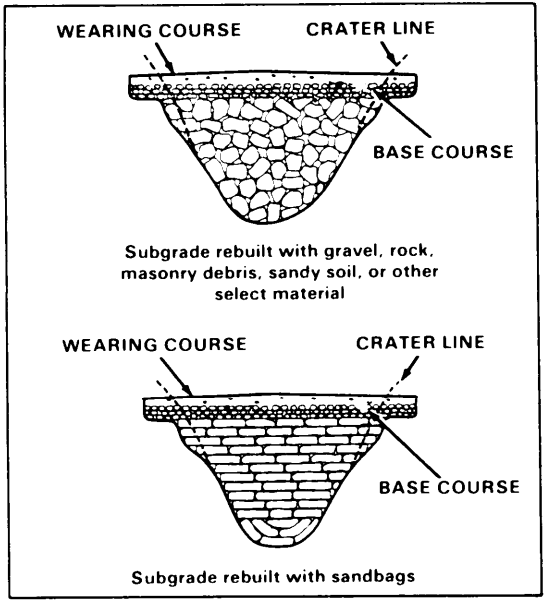



**Figure 2-24.** Crater repairs

## FORWARD AVIATION

### Army Aircraft and Helicopter Characteristics

See Tables 2-10 and 2-11 (page 2-24).

**Table 2-10.** Army helicopter characteristics

| NOMENCLATURE | NAME | LENGTH METERS (FEET) | ROTOR DIAMETER METERS (FEET) | HEIGHT METERS (FEET) | LOADED WEIGHT (1,000 LB) | EXTERNAL LOAD CAPACITY (1,000 LB) (NOTE) | CARGO WINCH CAPACITY (1,000 LB) |
|---|---|---|---|---|---|---|---|
| OH58 A/C | KIOWA | 12.5 (41) | 10.8 (35.4) | 3.1 (10.2) | 32* | — | — |
| CH47B | CHINOOK | 30 (98) | 18.3 (60) | 5.7 (18.7) | 40 | 20 | 3 |
| CH47C | CHINOOK | 30 (98) | 18.3 (60) | 5.7 (18.7) | 46 | 20 | 3 |
| CH47D | CHINOOK | 30 (98) | 18.3 (60) | 5.7 (18.7) | 50 | 28 | 3 |
| CH54A/B | CRANE | 27 (88.6) | 22 (72.2) | 7.5 (24.6) | 47* | 20/25 | 15/25 |
| UH 1 B/C/M | IROQUOIS | 16.1 (52.8) | 13.4 (44) | 3.9 (12.8) | 9.5 | 3 | — |
| UH 1 D/H/V | IROQUOIS | 17.5 (57.4) | 14.6 (48) | 4.4 (14.4) | 9.5 | 4 | — |
| UH60A | Black Hawk | 19.8 (65) | 16.3 (53.5) | 5.3 (17.4) | 20.25 | 8 | — |
| AH64 | APACHE | 17.4 (57.1) | 14.6 (48) | 3.8 (12.5) | 17.4 | 6 | — |
| AH15 | COBRA | 16.2 (53.1) | 13.4 (44) | 4.2 (13.8) | 10 | 1 | — |

NOTE: Maximum lifting capability

* Different for each model. Highest value represented.

**Table 2-11.** Combat area airfield requirements

| AIRFIELD TYPE | ANTICIPATED SERVICE LIFE | POSSIBLE USING AIRCRAFT US TYPE (NOTE 1) | GROUND RUN AT SEA LEVEL AND 59° FEET (NOTE 2) | MINIMUM RUNWAY LENGTH FEET | MINIMUM RUNWAY WIDTH FEET |
|---|---|---|---|---|---|
| Battle area | | | | | |
| Light lift | 3 days | C-7A* | 625 | 1.000 | 50 |
| Medium lift | | C-130* | 1.600 | 2.000 | 60 |
| | | C-123 | 1.600 | | |
| Forward area | 2 weeks | | | | |
| Liaison | | O-1* | 390 | 750 | 50 |
| Surveillance | | OV-1* | 2.000 | 2.500 | 60 |
| Light lift | | C-7A* | 625 | 1.200 | 60 |
| Medium lift | | C-130* | 2.000 | 2.500 | 60 |
| | | C-7A | 625 | | |

NOTES:

1. Asterisk shows particular aircraft that is critical in load and/or ground run from which area requirements, geometrics, and expedient surfacing requirements were developed.
2. Ground run lengths indicated are for classification and can undergo changes depending on operating weight of aircraft, pressure altitude corrections, temperature corrections, and local conditions.

### General Construction of Forward Landing Zone or Airstrip

Membrane or available timber may be used to construct an expedient hardened landing pad surface. Mark all obstacles in the landing zone or airstrip. Sprinkled water, lime, lime solutions, or oils will provide temporary dust control (Table 2-12). See Tables 2-13 and 2-14 and Figures 2-25 through 2-27 (pages 2-25 through 2-27) for landing zones and helipads geometric requirements.

**Table 2-12.** Dust control requirements for heliports

| AREA | DIMENSION OF AREA REQUIRING DUST CONTROL (FEET) | | |
|---|---|---|---|
| | UH-1D IROQUOIS | AH-1G HUEY COBRA | CH-47A CHINOOK |
| Taxi hooverlane and parking pads | 75 | 80 | 150 |
| Takeoff and landing areas | 132 | 150 | 295 |

NOTE:

Measurements are taken from the center of rotation of the controlling aircraft and are approximately equal to the radius of the area affected by the rotor downwash.

**Table 2-13.** Minimum geometric requirements for landing zones

| ITEM NO | DESCRIPTION | FORWARD AREA OH-58 | AH-1G | UH-1H | CH-47 |
|---|---|---|---|---|---|
| | LANDING PAD AND LANDING AREA | | | | |
| 1 | Length, feet | 15 | 20 | 20 | 50 |
| 2 | Width, feet | 15 | 20 | 20 | 25 |
| 3 | Landing area length, feet | 84 | 100 | 100 | 150 |
| 4 | Landing area width, feet | 84 | 100 | 100 | 125 |
| 5 | Parking pad grade in any direction, % maximum | 3 | 3 | 3 | 3 |
| 6 | Lateral clearance from rear and sides of parking pad to fixed and/or movable obstacles except other aircraft, feet | 30 | 45 | 45 | 65 |
| 7 | C-C spacing of parking pads, feet | 50 | 75 | 75 | 150 |
| 8 | Spacing from edge of taxi hoverlane to edge of parking pad, feet | 30 | 45 | 45 | 65 |

**Table 2-13.** Minimum geometric requirements for landing zones (continued)

| ITEM NO | DESCRIPTION | FORWARD AREA OH-58 | AH-1G | UH-1H | CH-47 |
|---|---|---|---|---|---|
| | **TAXI HOOVERLANE** | | | | |
| 9 | Width, feet (Note 1) | 90 | 140 | 140 | 180 |
| 10 | Longitudinal grade of taxi hoover-lane, % maximum | 10 | 10 | 10 | 10 |
| 11 | Transverse grade of taxi hoover-lane, % maximum | 5 | 5 | 5 | 5 |
| | **HELIPORT APPROACH AND DEPARTURE ZONE** | | | | |
| 12 | Approach-departure surface ratio | 10:1 | 10:1 | 10:1 | 10:1 |
| 13 | Length, feet | 1,500 | 1,500 | 1,500 | 1,500 |
| 14 | Width, feet | | | | |
| | a. At end of clear zone of taxi hoverlane | 90 | 140 | 140 | 180 |
| | b. At outer end | 850 | 850 | 850 | 850 |
| | **HELIPORT TAKE-OFF SAFETY ZONE** | | | | |
| 15 | Length, feet | 500 | 500 | 500 | 500 |
| 16 | Width, feet | SAME AS APPROACH DEPARTURE ZONE | | | |
| | **SERVICE ROADS** | | | | |
| 17 | Width, feet (Note 2) | 115 | 115 | 115 | 115 |

**NOTES:** 1. Taxi hoverlane is used for take-off and landing.
2. Roads should be located so as to require the least effort.

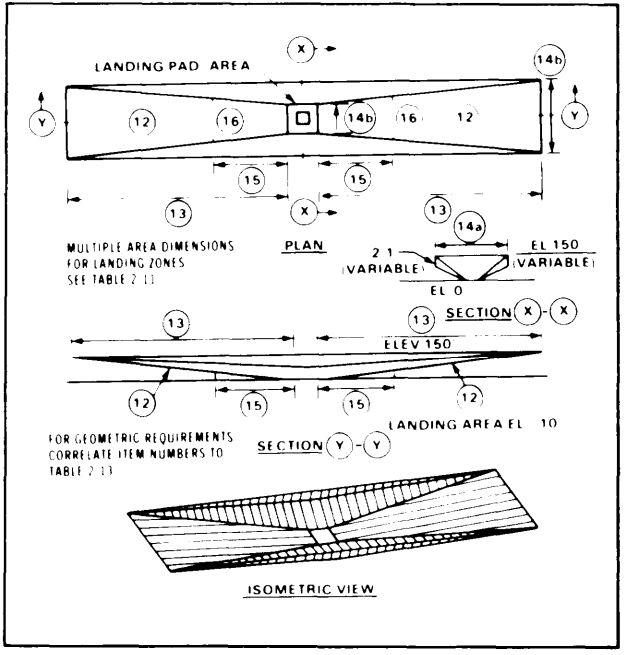



**Figure 2-25.** Geometric layout of landing zones

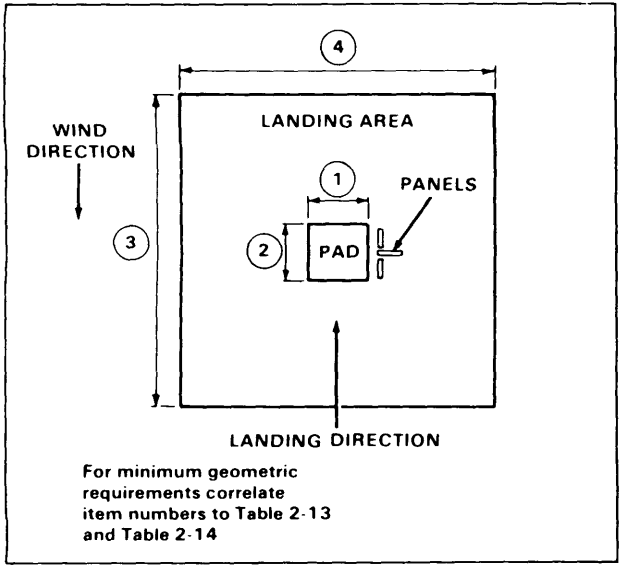



**Figure 2-26.** Panel layout of landing zones

**Table 2-14.** Minimum geometric requirements for multiple area landing zones

| ITEM NO | DESCRIPTION | FORWARD AREA UH-1 | FORWARD AREA CH-47 |
|---|---|---|---|
| 1 | One-ship landing zone | | |
| | Length | 100 | 150 |
| | Width | 100 | 125 |
| 2 | Two-ship trail landing zone | | |
| | Length | 180 | 250 |
| | Width | 100 | 125 |
| 3 | Two-ship side-by-side landing zone | | |
| | Length | 100 | 150 |
| | Width | 170 | 220 |
| 4 | Three-ship trail landing zone | | |
| | Length | 260 | 375 |
| | Width | 100 | 125 |
| 5 | Four-ship side-by-side trail | | |
| | Length | 180 | 250 |
| | Width | 170 | 220 |

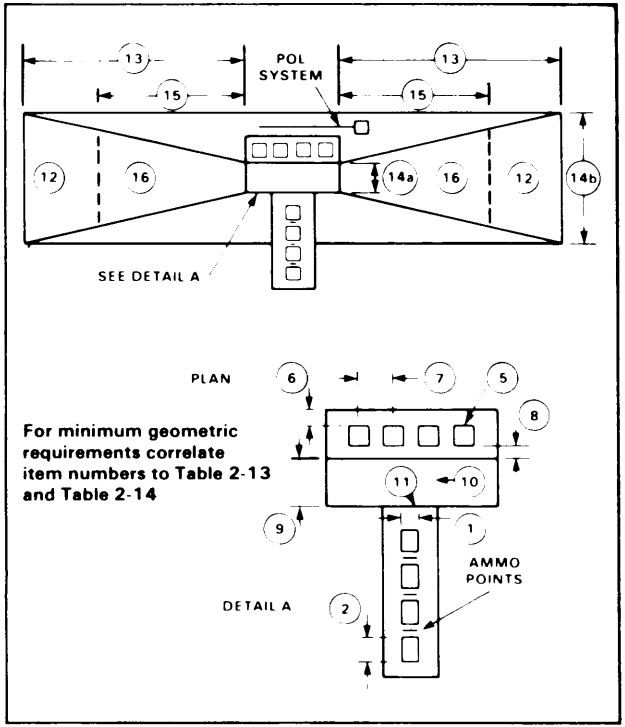



**Figure 2-27.** Geometric layout of forward area refueling and rearming heliports

### Maintenance and Repair

Maintenance and repair operations must be coordinated with tactical operations. Work should be done at night. Hazardous equipment must not be left on landing zone. Area under construction or repair must be clearly marked. Mud must be continuously removed. Remove all debris away from traffic and landing area for repair of all mats and membrane surfaces, see Chapter 8. Replace damaged timber and level accordingly.

# CHAPTER 3

## Countermobility

### THREAT OFFENSE

### Crossing Capabilities and Characteristics

**Table 3-1.** Threat equipment obstacle crossing capabilities and characteristics

| CHARACTERISTICS | MEDIUM TANK | | | LIGHT ARMOR (TRACKED) | | | | LIGHT ARMOR (WHEEL) | | LIGHT TANKS AND ASSAULT GUNS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Speed KMPH (MPH) | 60 (38) | | | 80 (55) | | | | 100 (63) | | 40 (25) | |
| Trench Crossing M (ft) | 2.8 (9) | | | 2.8 (9.2) | | | | 2.0 (6.6) | | 2.8 (9.2) | |
| Vertical Step M (ft) | .8 (2.6) | | | 1.1 (3.6) | | | | 4 (1.6) | | 1.1 (3.6) | |
| Gradeability ( ) | 30 | | | 38 | | | | 30 | | 38 | |
| Fording M (ft) | 1.4 (4.6) | | | Amphibious | | | | Amphibious | | 1.2/Amphibious | |
| Fording w/Kit M (ft) | 5.5 (18) | | | | | | | | | | |
| Height M (ft) | 2.3 (7.5) | | | 1.77 (5.8) | | | | 1.90 (6.2) | | 1.4 (4.6) | |
| VEHICLE | T54/55 | T62/64 | T72/80 | BTR | BMP | BMD | MT-LB | BRDM/2 | BTR60/70 | ASU57 | PT76/ ASU85 |
| Weight (MT) | 36 | 38 | 41 | 14.2 | 13.5 | 7.5 | 9.7 | 5.6/7 | 10.2/11 | 3.3 | 14 |
| Width M (ft) | 3.1 (10.2) | 3.4 (11.2) | 3.6 (11.8) | 2.55 (8.4) | | | | 2.17 (7.1) | | 2.0 (6.6) | 2.20 (7.2) |
| ARMAMENT | CALIBER | | EFFECTIVE RANGE METERS | CALIBER | | EFFECTIVE RANGE METERS | | CALIBER | EFFECTIVE RANGE METERS | CALIBER | EFFECTIVE RANGE METERS |
| Main | 125 | | 2.000 | 73/12.7 | | 800/1.500 | | 14.5 KPVT | 2.000 | 85 | 900 |
| Secondary | 7.62 PKT | | 1.000 | 7.62 | | 1.000 | | 7.62 PKT | 1.000 | 7.62 PKT | 1.000 |
| Auxiliary | 12.7 NSV | | 1.500 | AT3 Sagger | | 3.000 | | AT3 Sagger | 3.000 | 12.7 DSHK | 1.500 |

## Breaching Equipment

See Table 3-2 and Table 2-1 (page 2-3)

Table 3-2. Threat obstacle breaching equipment

**BRIDGES AND RAFTS**

| NOMENCLATURE | TYPE | LOAD CARRYING CAPACITY | TREADWAY WIDTH M (FT) | MAX GAP M (FT) | ASSY TIME METER (MINUTE) | ALLOCATION |
|---|---|---|---|---|---|---|
| PMP | Heavy pontoon | 60/170 [2] | 6.5 (21) | Per set 115 (377) | 7 | 18 bays per MRD/TD |
| TMM | Truck mounted | 60 | 3.8 (12.6) | Per span 10.5 (34) | 3.5 | 4 per MRR/TR<br>8 per MRD/TD |
| T54-MTU | Tank mounted | 50 | 3.2 (10.6) | 11 (36) | 3 [1] | 3 per TR<br>1 per MRR |
| MTU-20 | Tank mounted | 50 | 3.3 (10.8) | 18 (59) | 5 [1] | 1 per MRR<br>3 per TR |

NOTES: 1. Emplacement time
2. Class 60 for bridge and up to Class 70 for raft.

**AMPHIBIANS AND FERRY**

| NOMENCLATURE | TYPE | LOAD CARRYING CAPACITY (Kg) | PERSONNEL LOAD (SOLDIERS) | WIDTH M (FT) | HEIGHT M (FT) | SPEED KMPH (MPH) | ALLOCATION |
|---|---|---|---|---|---|---|---|
| K61 | Amphibian track | 5,000 | 50 | 3.2 (10) | 2.1 (7) | 36 (22) | 12 per MRD/TD |
| PTS-M | Amphibian track | 15,000 | 50 | 3.5 (11.5) | 3.4 (11.2) | 40 (25) | |
| PKP | Trailer | 5,000 | — | 2.8 (9) | 2.2 (7) | — | 3 per MRD/TD |
| GSP | Ferry | 50,000 | — | 21.5 (71) | 3.2 (10.6) | 7.7 (5) | 6 per MRD/TD |

**MINE DETECTORS/CLEARER**

| NOMENCLATURE | TYPE | SWEEPING/CLEARING | | | ALLOCATION |
|---|---|---|---|---|---|
| | | SPEED KMPH | WIDTH M (FT) | DEPTH CM | |
| UAZ69 DIM | Truck mounted mine detector | 10 | 22 (72) | 25 | 3 per MRD/TD |
| KMT 4/6 | Tank mounted mine plow | 10 | 2X.8 (2.5) | 10 | 9 per MRR<br>27 per TR |
| KMT 5 | Tank mounted plow/roller combination | 10 | 2X.8 (2.5) | 10 | 3 per MRR<br>9 per TR |
| BTR 50 PK UR 67 | APC with line charge | — | 2 @ 7 x 50 (22 x 160) | — | 2 per MRD/TD |

# OBSTACLES

## Countermobility Planning

The basic principles of obstacle employment are —

- Support the maneuver commander's plan.
- Integrate with observed fires, existing obstacles, and other reinforcing obstacles.
- Employ in-depth and for surprise.

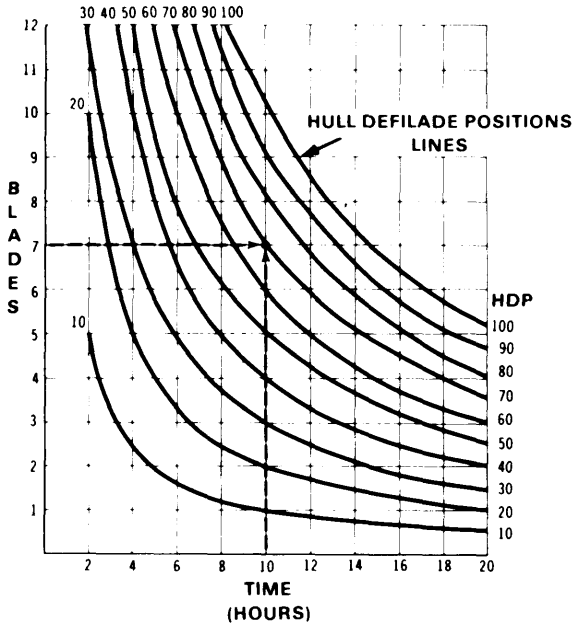
The supported commander must decide the effort to be used for countermobility and survivability tasks. Use Figure 3-1 to determine time and/or blade requirements for antitank ditches versus defilade positions. The following ratios are used in conjunction with Figure 3-1.

Ratio: $ATD = \frac{HDP}{40}$ and TDP = ATD (23.5)

Where: ATD = antitank ditch in kilometers
TDP = number of turret defilade positions
HDP = number of hull defilade positions

Example 1: You have seven blades and 10 hours of construction time. Your task force commander needs 20 turret defilade positions (TDP) and 2,000 meters of antitank ditch. The commander wants to know if you can do the job, and if not, give your recommendation.

Step 1. Enter Figure 3-1 with the number of blades and time. Find the number of hull defilade positions by reading the appropriate line (interpolate between lines): HDP = 70 (see dotted line Figure 3-1).




**NOTES:** 1. A 20 percent factor for travel time is included.
2. If blades or hours exceeds the graph, see example 2.
3. For NBC environment see Table 1-9 (page 1-26) for degradation.
4. Digging rates are considered conservative, change the graph value IAW on site sample digging.

**Figure 3-1.** Hull defilade positions graph

Step 2. Using the ratios, convert HDP to ATD and TDP.

$$ATD = \frac{HDP}{40} = \frac{70}{40} = 1.75 \text{ km}$$

TDP = ATD (23.5) = 1.75(23.5) = 41.1 —> 41 positions

Step 3. Using values obtained in steps 1 and 2, construct the following graph (Figure 3-2).

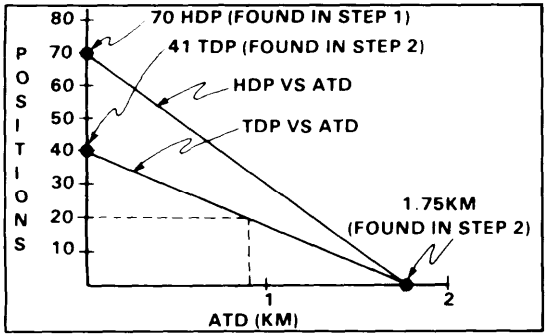



**Figure 3-2.** Example

Step 4. On the constructed graph, enter 20 (number of TDPs needed) and move horizontally to the TDP versus ATD line. Now move down to find out how many meters of ditch you can construct (see dotted lines on sample graph, Figure 3-2): .9 km = 900M.

Step 5. Inform the task force commander that you can construct the 20 TDPs, but only 900 meters of ATD. To construct the additional 1,100 meters of ATD, you need five more blades or 7 more working hours.

NOTE: Here is a simple method to obtain the additional time or blades required as stated above.

**Additional time needed:**

$$1.1 \text{ km (requirement)} \quad \frac{HDP}{40} \text{ —> } HDP = 40(1.1) = 44 \text{ positions}$$

Enter Figure 3.1 with seven blades and move horizontally until the 44 HDP is found (between HDP 40 and 50) read down for additional time = 6.5 —> 7 hours.

**Additional blades needed:**

Enter 10 hours (time constraint) on chart. Move up until the 44 HPD is found (interpolation required) read number of blades needed on left = 4.5 —> 5 blades.

Example 2: You have 20 blades and 10 hours. How many hull defilade positions can you construct?

Step 1. Since the number of blades exceed graph range, divide the blades by any number. For the example use 5.

$$\text{New number of blades} = \frac{20}{5} = 4 \text{ blades}$$

Step 2. Enter 10 hours and the new number of blades in step 1 (4 blades) on the chart to obtain HDP.

HDP = 40 positions

Step 3. Multiply the HDP found in step 2 (40 HDP) by number used to divide blades in step 1 (5).

HDP = 40 x 5 = 200 positions

Step 4. You may proceed with step 2 in Example 1 as required.

## Barbed wire and concertina

Whenever U-shaped pickets are used, the open end of the U must face toward the enemy

Table 3-3. Wire and tape entanglement material

| MATERIALS | APPROX. WEIGHT, KG | APPROX. LENGTH, M | NO. CARRIED BY ONE SOLDIER | APPROX. WEIGHT OF MAN-LOAD KG |
|---|---|---|---|---|
| Barbed wire reel | 41.5 | 400 | -- | 21 |
| Bobbin | 3.5—4.0 | 30 | 4—6 | 14.5—24.5 |
| Barbed tape dispenser | 0.77 | 0.45 | 20 | 15.5 |
| Barbed tape carrying case | 14.5 | 300 | 1 | 14.5 |
| Standard barbed tape concertina | 14 | 15.2 | 1 | 14 |
| Standard barbed wire concertina | 25.4 | 15.2 | 1 | 25 |
| General purpose barbed tape obstacle | | | | |
| Hand | 15.8 | 20 | 1 | 15.8 |
| Vehicular | 117.9 | 140 | 25 | 29.5 |
| U-shaped pickets | | | | |
| Long | 4.5 | 1.5 | 4 | 18.1 |
| Medium | 2.7 | 0.81 | 6 | 16.3 |
| Short | 1.8 | 0.61 | 8 | 14.5 |

Table 3-4. Material and labor requirements for 300-meter sections of various wire entanglements

| TYPE OF ENTANGLEMENT | PICKETS LONG | PICKETS MED | PICKETS SHORT | REELS OF BARBED WIRE [1] | NO. OF GPBTO | NO. OF CONCERTINAS | STAPLES | MAN-HOURS TO ERECT [3] | KG OF MATERIALS PER LIN M OF ENTANGLEMENT [2] |
|---|---|---|---|---|---|---|---|---|---|
| Double-apron, 4- and 2-pace | 100 | | 200 | 15-16 (19) [4] | | | | 71 | 4.6 (3.5) [5] |
| Double-apron, 6- and 3-pace | 66 | | 132 | 15-17 (18) [4] | | | | 59 | 3.6 (2.6) [5] |
| High wire (less guy wires) | 198 | | | 19-21 (24) [4] | | | | 95 | 5.3 (4.0) [5] |
| Low wires, 4- and 2-pace | | 100 | 200 | 11 | | | | 59 | 3.6 (2.8) [5] |
| 4-strand fence | 100 | | 2 | 6-7 (7) [4] | | | | 24 | 2.2 (1.8) [5] |
| Triple standard concertina | 160 | | 4 | 3 (4) [4] | | 59 | 317 | 30 | 8.2 (7.3) [5] |
| General purpose barbed tape obstacle (GPBTO) | | | | | (8) [6] | | | (1) [6] | 2.7 |

NOTES: 1. Lower number of reels applies when U-shaped pickets are used; higher number if wooden pickets are used. If only one number, use for both pickets.

2. Average weight when any issue metal pickets are used (1 truckload = 2,268 kg).

3. Man-hours are based on the use of driven pickets. Multiply these figures by .67 if experienced troops are being used, and by 1.5 for night work.

4. Number of barbed tape carrying cases required if barbed tape is used in place of barbed wire.

5. Kilograms of material required per linear meter of entanglement if barbed tape is used in place of barbed wire and barbed tape concertina is used in place of standard barbed wire concertina.

6. Based on vehicular emplaced obstacles installed in triple belts.

**Entanglements.** Entanglements are classified according to their use. The quantity of concertina required can be estimated using the following rules of thumb:

- Conventional deployment along forward edge of battle area (FEBA)(Figure 3-3).
  - -Tactical wire = (front) x (1.25) x (number of belts).
  - -Protective wire = (front) x (5) x (number of belts).
  - -Supplementary wire:
    - Forward of FEBA (front) x (1.25) x (number of belts).
    - Rear of FEBA = (2.5) x (unit depth) x (number of belts).

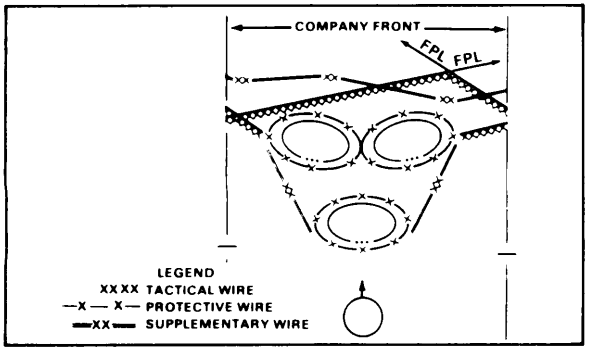



**Figure 3-3.** Schematic layout of barbed wire entanglements in a defensive area

- Base camp defense along perimeter (Figure 3-4).
  - -Tactical wire = (mean perimeter) x (1.25) x (number of belts).
  - -Protective wire = (perimeter) x (1.10) x (number of belts).
  - -Supplementary wire = (mean perimeter) x (1.25) x (number of belts).

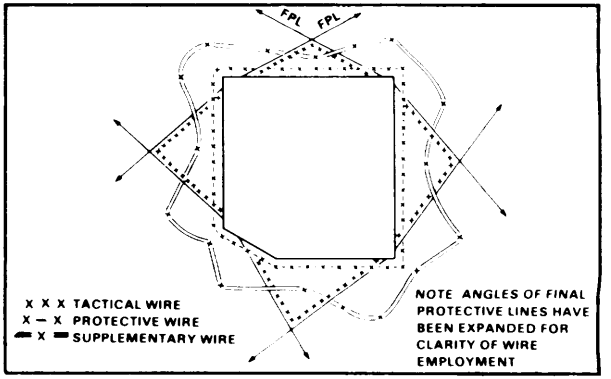



**Figure 3-4.** Perimeter defense wire

- Ensure job site security.
- Organize work party into three equal crews.
- First two crews lay out pickets and third crew installs pickets (open end of U toward enemy).
- Reorganize party into crews of two to four soldiers.
- Install wire in numerical order as shown in Figure 3-5.
- Avoid having any soldier cut off between the enemy and the fence.
- Ensure that wires are properly secured and tight.

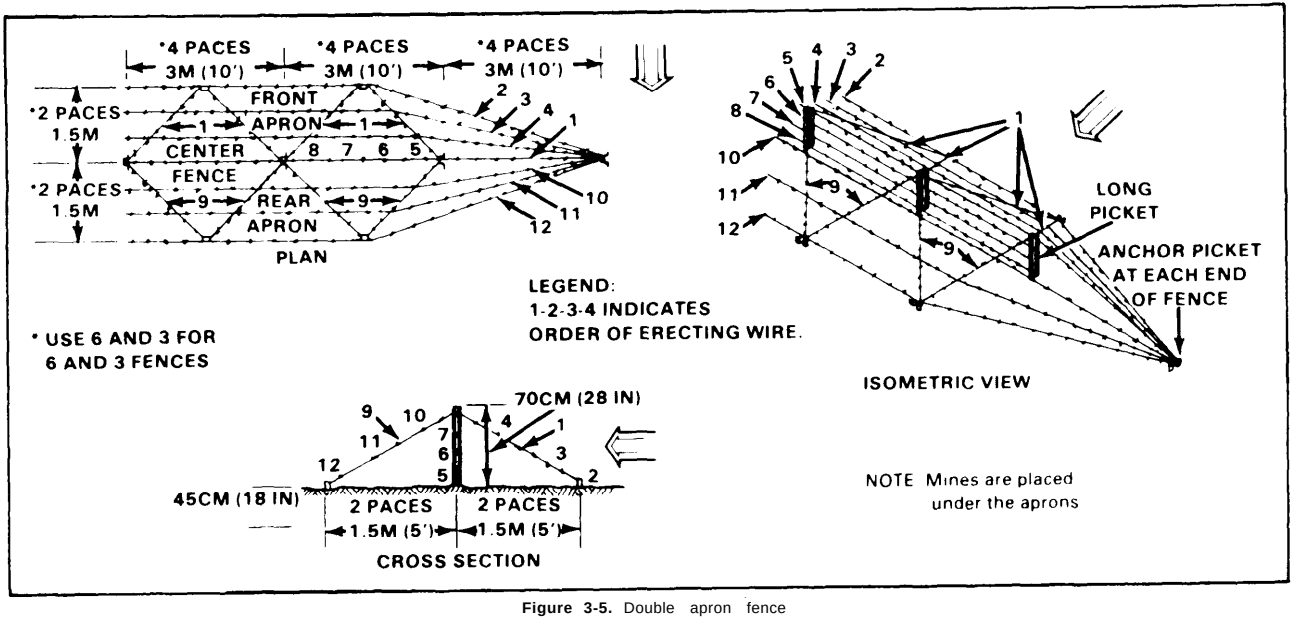



**Figure 3-5.** Double apron fence

**Triple standard concertina.** See Figures 3-6 through 3-8.

- Ensure job site security.
- Organize work party into three crews.
- First crew lays pickets (Figure 3-6).
- Second crew lays out concertina. Place one roll on enemy side at every third picket and two rolls on friendly side at every third picket.
- Third crew installs all pickets.
- Reorganize party into four-soldier crews.
- Install concertina (Figures 3-7 and 3-8).
- Ensure concertina is properly tied and all horizontal wire properly installed.

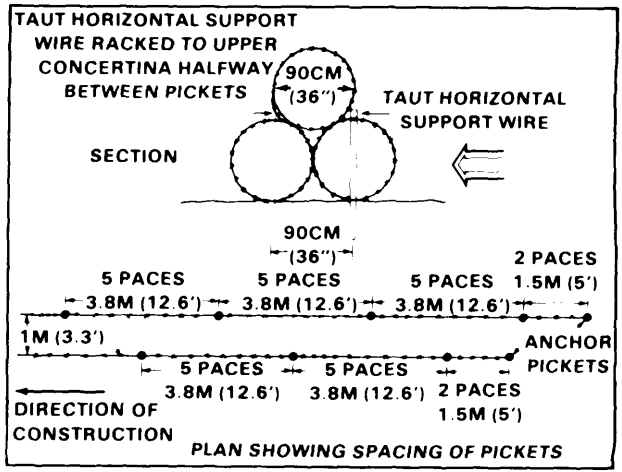



**Figure 3-6.** Triple standard concertina fence

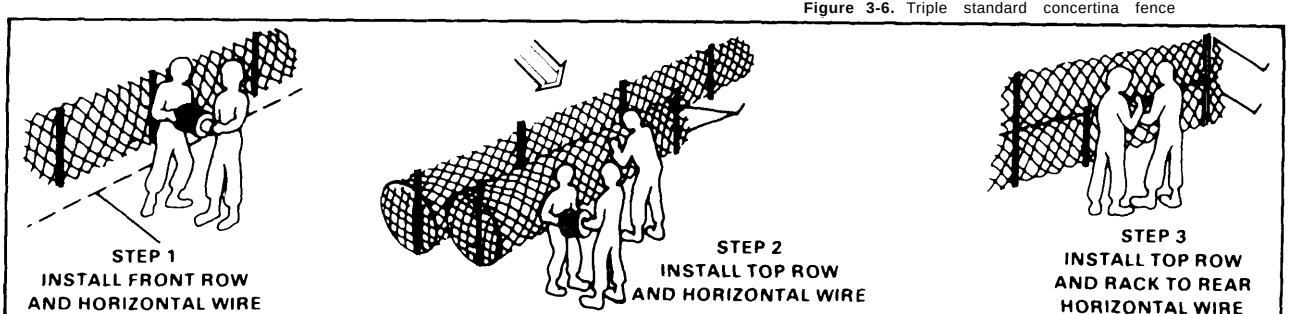



**Figure 3-7.** Installing concertina

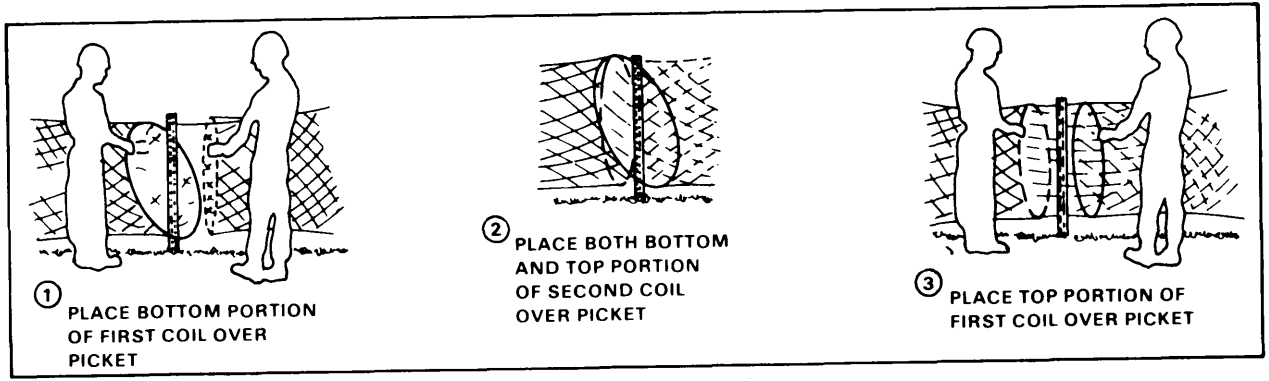



**Figure 3-8.** Joining concentina

**Four-strand cattle fence.** See Figure 3-9.

- Ensure job site security.
- Organize work party into four soldier crews.
- First crew lays out long pickets 3 meters (10 feet) apart and second crew installs pickets.
- Reorganize party into two-soldier teams, one team carries the reel and the other team makes the ties.

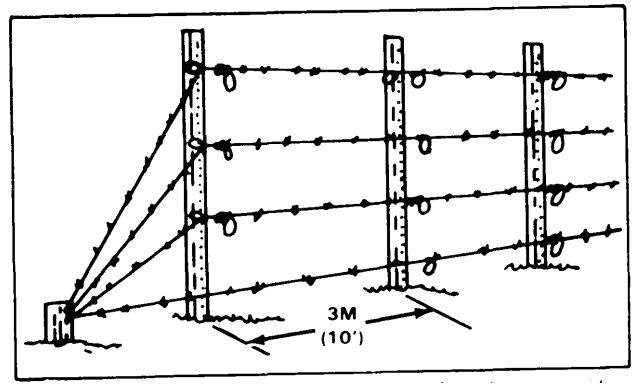



**Figure 3-9.** Four-strand cattle fence as viewed from the enemy side

**General purpose barbed tape obstacle (GPBTO).** The barbed tape (Figure 3-10) comes in seven modules (20 meters per module) per package. One package contains 140 meters of barbed tape (single belt). The GPBTO may be installed by vehicle or by individual soldier. It should be installed in three-band belts. Anchor one end and carry the package along installation path. Gloves **should not** be worn during installation since barbs will easily penetrate them.

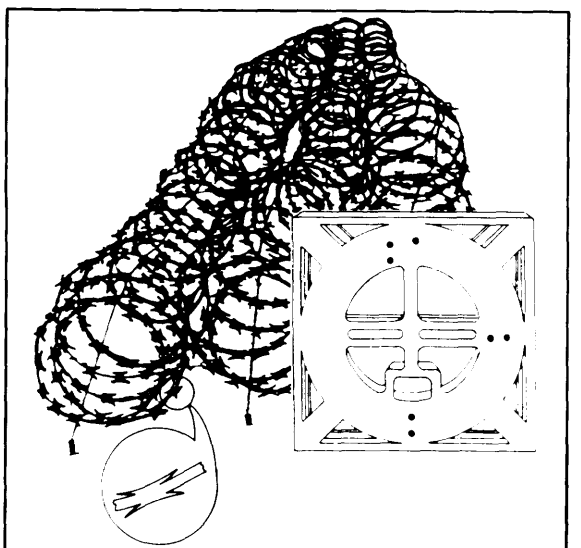


**Figure 3-10.** General purpose barbed tape obstacle

**Other wire obstacles.** Construction sequence for other wire obstacles should be from enemy to friendly and from bottom up (Figures 3-11 through 3-14).

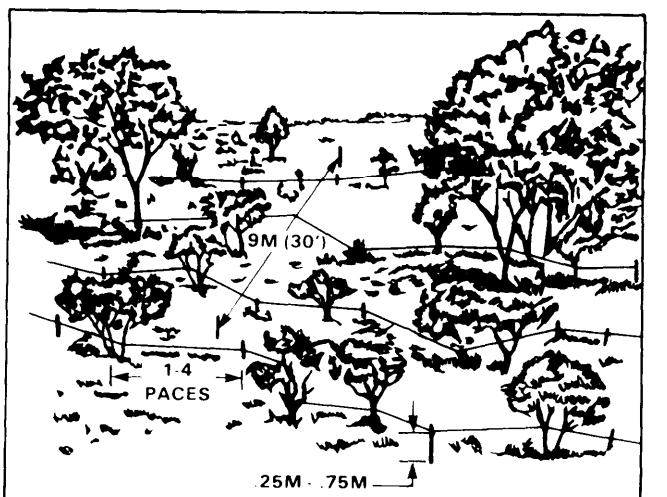



**Figure 3-11.** Tanglefoot

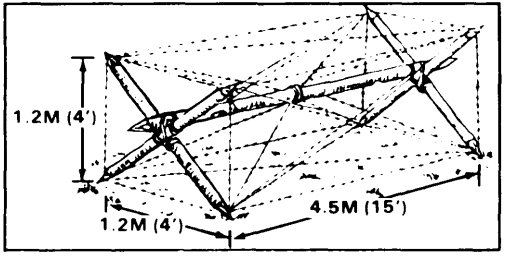



**Figure 3-12.** Knife rest

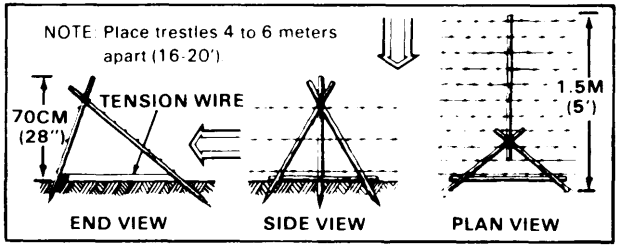



**Figure 3-13.** Trestle apron fence

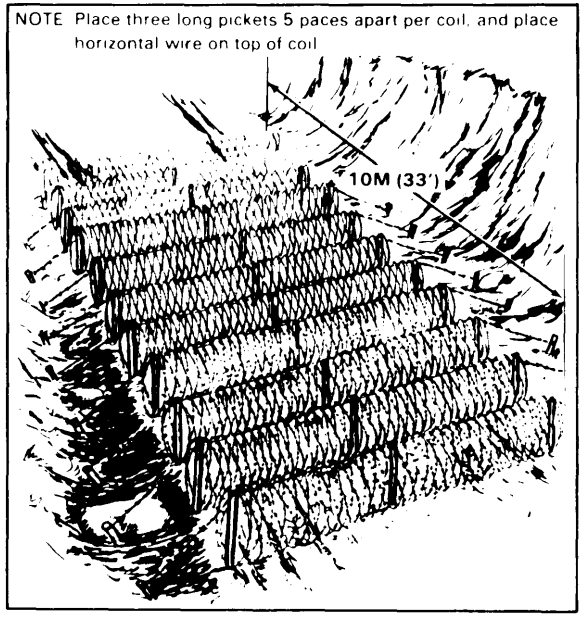



**Figure 3-14.** Concentina roadblock

**Antivehicular obstacles**

**Antitank ditches and road craters.** See Figure 3-15. Refer to Chapter 6 for specific details and construction of road craters.

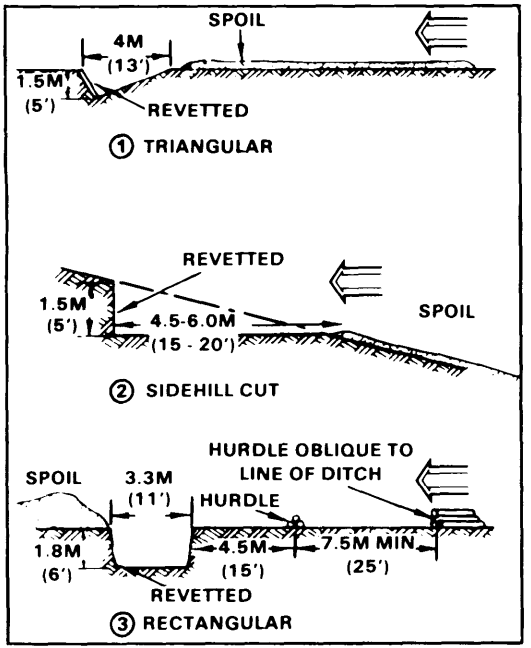



**Figure 3-15.** Antitank ditches

**Log cribs.** See Figures 3-16 and 3-17 and Table 3-5.

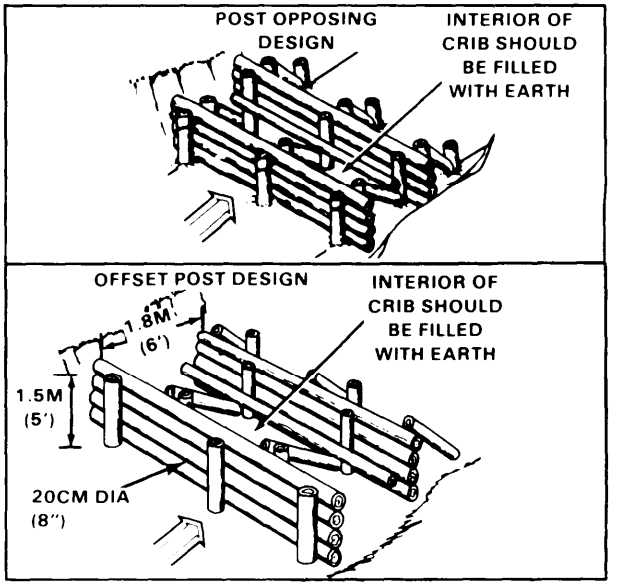



**Figure 3-16.** Retangular log cribs design

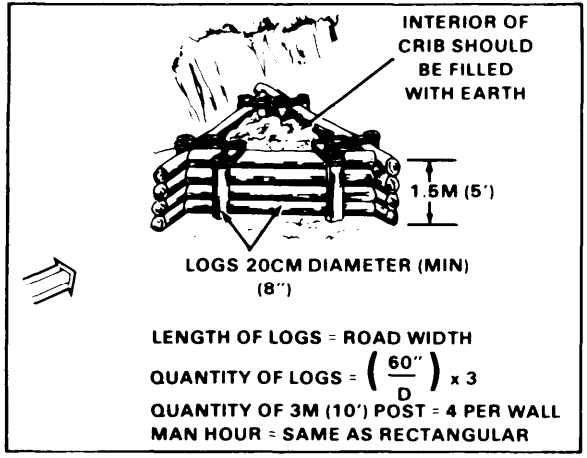



**Figure 3-17.** Triangular log crib

**Wall logs requirement -** Length = roadway width

$$\text{Quantity} = \frac{120}{D} + 1$$

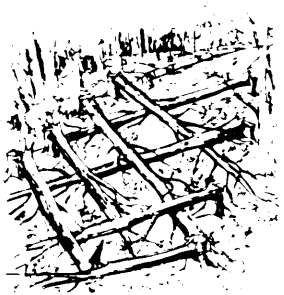
D = log diameter in inches

**Manpower requirement -** A 20-foot wide road requires 4 to 8 engineer platoon hours when equipped with hand-tools.

**Table 3-5.** Post requirement (post opposing/offset post)

| POSTS \ ROAD WIDTH METERS (FEET) | 1.8 (6) | 2.1 - 3.6 (7 - 12) | 3.9 - 5.4 (13 - 18) | 5.8 - 7.3 (19 - 24) | 7.6 - 9.1 (25 - 30) | 9.4 - 10.9 (31 - 36) | 11.3 - 12.8 (37 - 42) | 13.1 - 14.6 (43 - 48) |
|---|---|---|---|---|---|---|---|---|
| Long. 3 (10) | 8 / 6 | 12 / 10 | 16 / 14 | 20 / 18 | 24 / 22 | 28 / 26 | 32 / 30 | 36 / 34 |
| Short. 2.1 (7) | 2 / 2 | 3 / 3 | 4 / 4 | 5 / 5 | 6 / 6 | 7 / 7 | 8 / 8 | 9 / 9 |
| Braces. 2.1 (7) | 4 / 3 | 6 / 5 | 8 / 7 | 10 / 9 | 12 / 11 | 14 / 13 | 16 / 15 | 18 / 17 |

**Abatis.**



- MINIMUM DEPTH: 75M (246')
- TREE DIAMETER: 64 CM (2')
- TREE HEIGHT: 6M (20')
- DROP TREE 45° TOWARD ENEMY
- TREE SHOULD REMAIN ATTACHED TO STUMP
- LB (TNT) = $\frac{D^2}{50}$
- USE TEST SHOT TO DETERMINE ACTUAL DEMOLITION NEEDED
- WORK RATE: 75M (246') 8 PLATOON HR

**Figure 3-18.** Abatis

**Log hurdles.** Log hurdles should be sited at steepest part of slope (Figure 3-19).

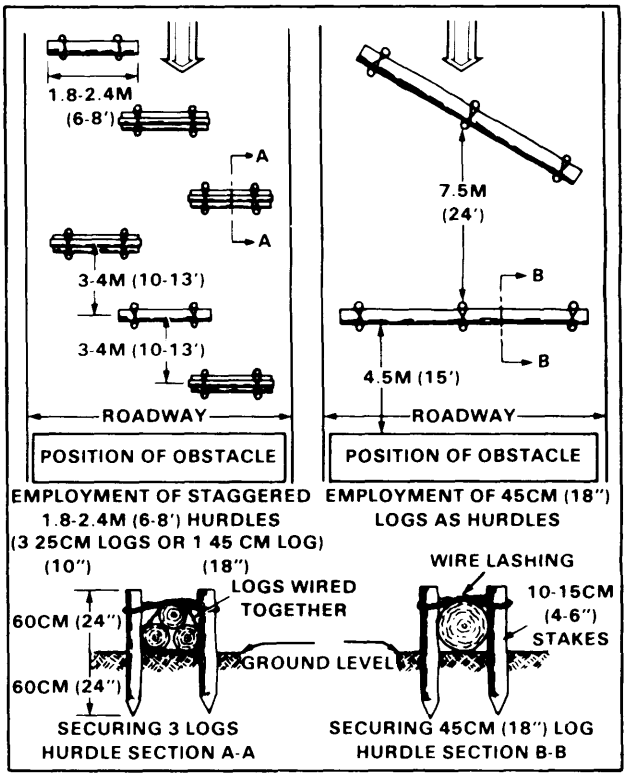
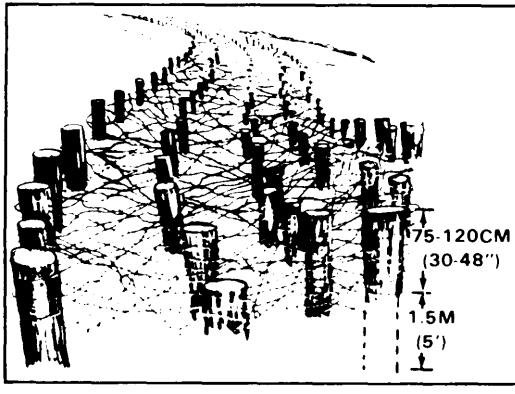



**Figure 3-19.** Types of log hurdles

Log/steel post obstacle.




$$\text{NO. OF POST} = \frac{\text{FRONT}}{1.5} \times \text{NO. OF ROWS (MINIMUM 4 ROWS)}$$

SPACING: IRREGULAR, 1 TO 2 METERS
HEIGHT: IRREGULAR, 75-120CM (30-48")
1.5 METERS UNDER GROUND
DIAMETER: MINIMUM 40CM (16")

$$\text{TIME} = \left(\frac{\text{FRONT}}{6\text{M}}\right) \times \text{WORK RATE}$$

FRONT = IN METERS ASSUMING FOUR ROWS

WORK RATE: 4-6 HR (2 NCOs, 16 SOLDIERS, PILE DRIVER)
2-2½ HR (1 NCO, 8 SOLDIERS, POWER AUGER)
3-5 HR (PLATOON USING HAND-TOOLS)

**Figure 3-20.** Post obstacles

**Hedgehog and tetrahedrons.**

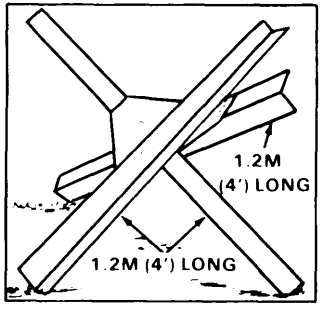



**Figure 3-21.** Steel hedgehog

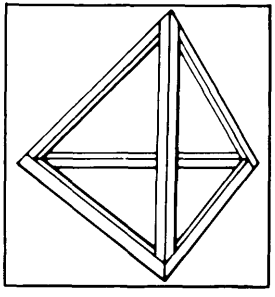


**Figure 3-22.** Steel tetrahedron

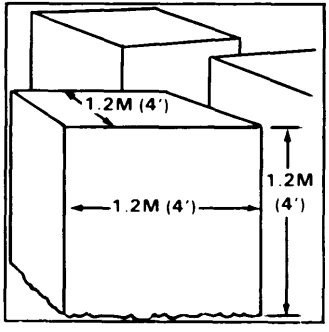



**Figure 3-23.** Concrete cubes

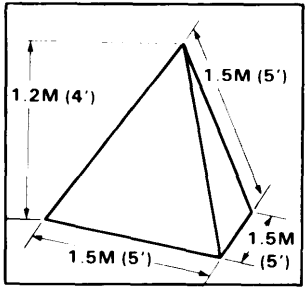



**Figure 3-24.** Concrete tetrahedron

## Minefield Type and Development

**Table 3-6.** Minefields types and characteristics

| TYPE | DESCRIPTION | TACTICAL USE | REPORTS REQUIRED | RECORDS REQUIRED | MINES USED | | | AUTHORITY (DELEGATED TO) |
|---|---|---|---|---|---|---|---|---|
| | | | | | AP | AT | SCAT | |
| Hasty Protective | Above ground Random pattern No antihandling devices | Aids in unit local close in protection of defensive perimeter | Intention Initiation Completion Change/ Removal | DA Form 1355-1-R to parent unit | X | X | X | Bde Cmdr (Bn/Co Cmdr) |
| Deliberate Protective | Standard pattern Fenced and marked | | As above sent to authorizing HQ | DA Form 1355 to authorizing HQ | X | X | | Div Cmdr (Inst Cmdr) |
| Tactical | Standard or random pattern Scatterable | As part of obstacle plan | As above | DA Form 1355 to authorizing HQ | X | X | X | Div Cmdr (Bde Cmdr) |
| Point | Random pattern Surface or buried | Enhance obstacles Hinder use of key areas | As above | As above | X | X | X | Bde Cmdr (Bn Cmdr) |
| Interdiction | Placed on or behind enemy location | Separate, destroy, and disrupt enemy | As above | As above after execution | | | X | Corps Cmdr (Div Cmdr) |
| Phony | Same as live minefield being simulated | Simulate other minefield | Same as simulated | Same as simulated | | | | Same as simulated |

NOTES: 1. Corps Commander is the initial employment authority for all scatterable minefields.
- Long self-destruct (> 24 hrs) may be delegated to division and brigade level.
- Short self-destruct (< 24 hrs) may be delegated to battalion/task force level.

2. Use scatterable minefield report and records for all scatterable minefields.

## Conventional Minefields

### Reports

All minefields are reported by the fastest secure means available and are classified SECRET when completed. Exact format may be specified by local command SOP.

**Intention to lay.**

**Table 3-7.** Report of intention to lay with example

| EXPLANATION | LETTER DESIGNATION | EXAMPLE |
|---|---|---|
| Tactical objectives (temporary security roadblock or other) | ALFA | Bridge work site security |
| Type of minefield | BRAVO | Hasty protective |
| Estimated number and types of mines and whether surface laid mines or mines with antihandling devices | CHARLIE | 10 each M18A1 No. AHD |
| Location of minefield by coordinates | DELTA | UT 0976 |
| Location and width of minefield lanes and gaps | ECHO | Rt. 67 No.— south approach to bridge |
| Estimated starting and completion date-time group | FOXTROT | Start 190700 May 87 Completion 190800 May 87 |

**Initiation.**

**Table 3-8.** Report of initiation with example

| EXPLANATION | LETTER DESIGNATION | EXAMPLE |
|---|---|---|
| Location of minefield by coordinates | DELTA | UT 0976 |
| Estimated starting and completion date-time group | FOXTROT | Start 190700 May 87 Completion 190800 May 87 |

**Progress.**

**Table 3-9.** Report of progress with example

| EXPLANATION | LETTER DESIGNATION | EXAMPLE |
|---|---|---|
| Location of minefield by coordinates, 25%, 50%, 75%, or 100% completed | DELTA | UT 0976, 25% completed |

**Completion.** See Table 3-10. A completion report should be followed by a minefield record.

**Table 3-10.** Report of completion of minefield with example

| EXPLANATION | LETTER DESIGNATION | EXAMPLE |
|---|---|---|
| Changes in information submitted in intention to lay report | ALFA | None |
| Total number and type of AT and AP mines laid | BRAVO | M15—299<br>M26—865<br>M14—601 |
| Date and time of completion | CHARLIE | 231800 Mar 87 |
| Method of laying mines (buried by hand or by machine) | DELTA | Buried by hand |
| Details of lanes and gaps including marking | ECHO | WD1 wire on ℄ AZ 270° Ent and Ex marked with 2U pickets |
| Details of perimeter marking | FOXTROT | Standard fence |
| Overlay showing perimeter, lanes, and gaps | GOLF | NA |
| Laying unit and signature of individual authorizing laying of of the field | HOTEL | 2d Plt, Co A, 546th Engr Bn (C) |

**Transfer.** A transfer report is used when minefield responsibility istransferred between commanders. It must be signed by both commanders and include a certificate stating that receiving commander was shown or informed of all mines within the zone of responsibility and that the receiving commander takes full responsibility for all the mines within the zone. The report is sent to the higher commander who has authority over both relieved and relieving commanders.

**Change.** A change report is submitted when any alterations are made to a minefield for which a completion report and record have been submitted.

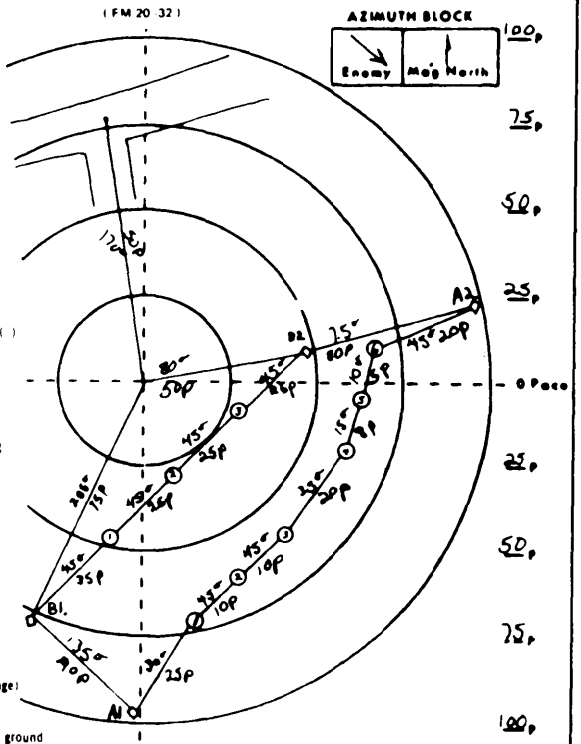
## HASTY PROTECTIVE MINEFIELD RECORD

(FM 20-32)

Instructions

1. Designate an easily identifiable reference point on the ground (a tree, a stump, a stake or the like). Orient the form (the blank form on the reverse) by tying in the center point of circles to the designated reference point on the ground.
2. Tie in reference point to a land mark, such as a road junction or house corner, that can be found on a standard military map.
3. Complete the azimuth block.
4. Complete the following information in the identification block: unit, ref pt, remarks, map, and sheet no, OIC, name SSAN.
5. Starting from the reference point record the magnetic Azimuth in degrees (°) and distance in paces (P) of each leg from the friendly position toward the enemy position and from right to left or left to right across each row of mines. However, all rows must be recorded in the same direction. Whichever direction is used, the starting points of the rows must be marked A1, B1, and so forth, and the ending points marked A2, B2, as shown in the example. Each mine in each row will be numbered sequentially from the starting point to the last mine in the row.
6. Fill in the tabular block. (See example.)
7. Fill in the scale being used where space is provided: scale 2cm = and fill in the pace (p) readings in the right margin.
8. Make all minefield reports (intention, initiation, completion, transfer, and change) by some secure means.
9. Note what has been used to identify A1 and B1: such as 2x4 driven flush with ground, steel pickel or fence post wrapped with engineer tape, and so forth.

*SCALE: 2cm = 25 paces




### TABULAR BLOCK

| Row | Type | Actuation | Mine number |
|---|---|---|---|
| A | M18A1 | Tripwire | 1, 2, 6 |
| | M21 | Controlled | 3, 4, 5 |
| B | M18A1 | Tripwire | 1, 3 |
| | M18A1 | Pressure | 2 |
| | | | |
| | | | |

Remarks: ANOMALY IS ROAD JUNCTION AT NA123492409

### IDENTIFICATION BLOCK

| | |
|---|---|
| Unit 2ND PLT A Co 1-4th 2 BDE, 1CAV DIV | |
| Ref Pt TREE STUMP SIDE OF ROAD | |
| Remarks: POINTS A1 & A2, B1 & B2 ARE MARKED WITH 1"x2" STAKES | |
| Map & Sheet No TALBOT 5566 | |
| Name of OIC W ALLAN | |
| Signature [illegible] | Time & Date 1400 25 |
| Mines removed | |
| Mines transferred | |

DA FORM 1365 1 R

*Scale = (Distance from RP to farthest point in field + 10 paces)/4

Example = (90 paces and + 10 paces)/4 = 25 paces/ring

Figure 3-25. Hasty protective minefield record

**Row minefield**

**Development.** See Figure 3-26.

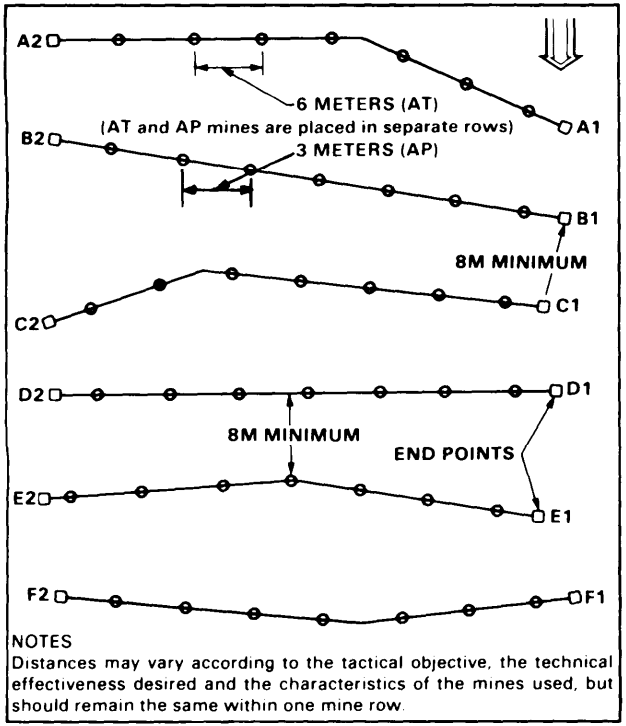



**Figure 3-26.** Row pattern minefield

**Logistical requirements.**

NUMBER OF MINES AND MINEFIELD ROWS

Step 1. The number of mines required is equal to the desired density times the minefield front. A 10 percent excess factor is included by multiplying by 1.10.

| Density | Front |
|---|---|

0.5 x 400 x 1.10 = 220 AT

Step 2. The number of AT mines per row is determined by dividing the minefield front by the spacing interval between AT mines (normally 6 meters between mines).

400 meters ÷ 6 meters = 66.6 AT mines per row

NOTE: The resulting number is rounded DOWN to the nearest whole number.

66.6 becomes 66 AT mines per row

Step 3. The number of rows needed in the minefield is equal to the number of AT mines required (step 1 ) divided by the number of AT mines per row (step 2). The resulting number is rounded UP to the nearest whole number.

220 AT mines ÷ 66 AT mines per row = 3.3 rounded UP to 4 rows

NUMBER OF TRUCKLOADS

The number of truckloads required for minefield emplacement depends on the type and quantity of mines and vehicular carrying capacity. See Table 3-13 (page 3-26).

The number of truckloads required is equal to the total number of AT mines divided by the truck's capacity. In this example, 5-ton dump trucks are used.

220 ÷ 204 = 1.08, rounded UP to the next higher whole number = 2 truckloads

**Recording.** See Figures 3-32 through 3-37 (pages 3-27 througth 3-32).

**Standard pattern minefields**

Development. See Figures 3-27 througth 3-31 (pages 3-21 through 3-24).

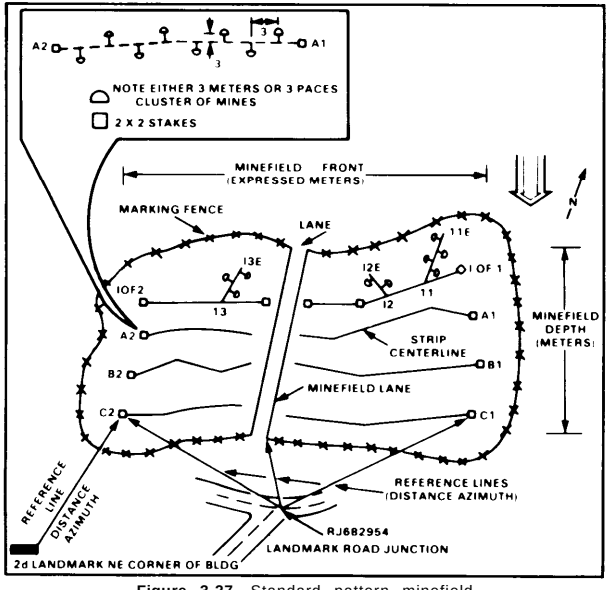



**Figure 3-27.** Standard pattern minefield

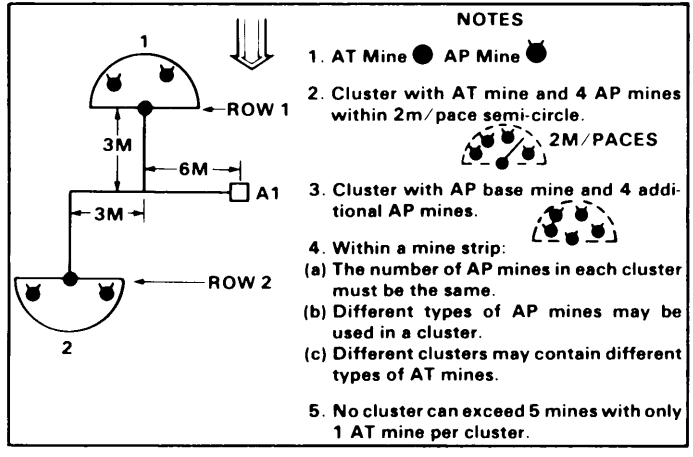
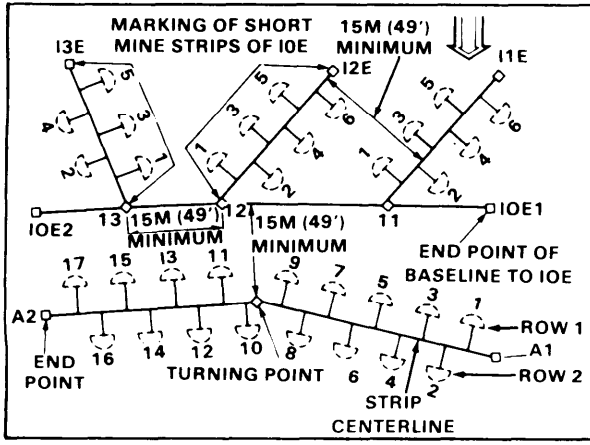


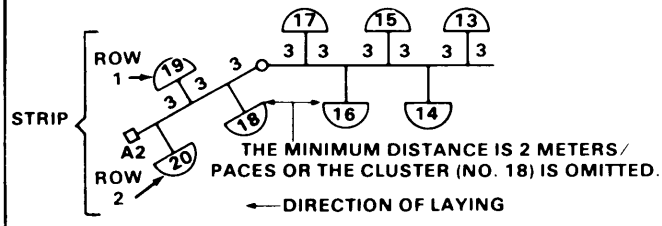

**Figure 3-28.** Mine cluster characteristics




NOTES:

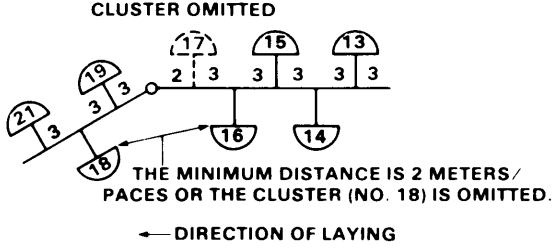
1. Marking of end points with A1 and A2, for example, will indicate laying direction of a minefield.
2. Laying will always begin at point No. 1.
3. Odd numbers on enemy side of the strip.
4. Strip start and end points, and turning points will be marked with a 2" x 2" wooden stake.
5. Distance between strip centerlines is 15 meters minimum.
6. Marking end point stakes should be driven flush with the ground and a nail driven on its center to aid detection with mine detector.

**Figure 3-29.** Irregular outer edge characteristics



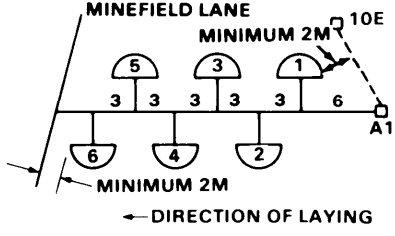

The last cluster before and the first cluster after the turning point will have a distance of 3 meters/paces from the turning point and are laid on opposite sides of the strip centerline.

An omitted cluster is numbered when it is necessary to maintain the normal numbering sequence and omitted clusters so numbered must be noted in the "Notes" section of the minefield record (DA Form 1355).




If the distance is less than 3 meters/paces between the last possible cluster and the turning point, the cluster will not be omitted.

The first cluster after the turning point will be laid on the opposite side of strip centerline from the last laid cluster and 3 meters/paces from the turning point.




First cluster of strip will not be closer than 2 meters to the line joining the end points of mine strips.

**Figure 3-30.** Minefield row and strip characteristics

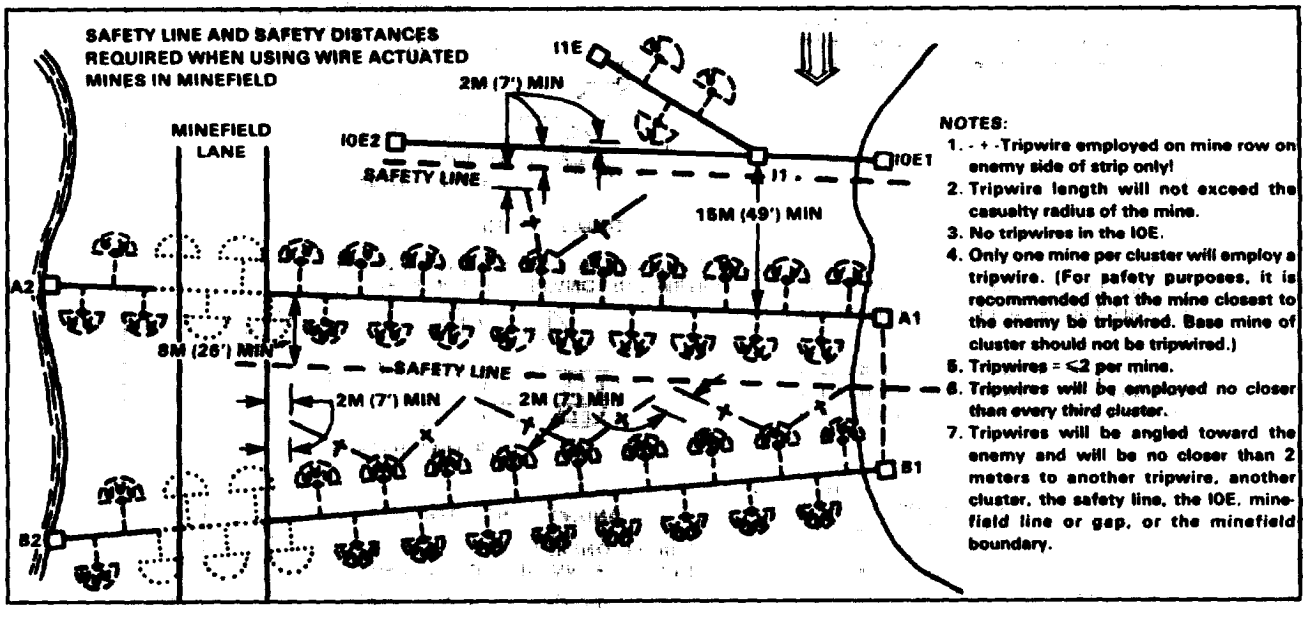



Figure 3-31. Tripwire employment

**Organization.**

**Table 3-11.** Platoon organization for standard pattern minefield

| PERSONNEL | OFFICER | NCO | EM | EQUIPMENT |
|---|---|---|---|---|
| Supervisory personnel | 1 | 1 | | Officer: Map, lensatic compass, notebook, and minefield record forms.<br>NCO: Map, notebook, and lensatic compass. |
| Siting party | | 1 | 3 | Stakes or pickets, sledgehammers, tracing tape on reels, and nails to peg tape. |
| Marking party | | 1 | 2 | Barbed wire on reels, marking signs, lane signs, wire cutters, gloves, sledgehammers, and pickets. |
| Recording party | | 1 | 2 | Sketching equipment, lensatic compass, minefield record forms, maps, and metric tape. |
| First laying party | | 1 | 6 to 8 | Notebook for squad leader, picks, shovels, and sandbags. |
| Second laying party | | 1 | 6 to 8 | Same as first laying party. |
| Third laying party | | 1 | 6 to 8 | Same as first laying party. |
| Total | 1 | 7 | 25 to 31 | |

NOTE: Organization may vary depending on terrain, soldiers, and materials available and the proximity of the enemy.

**Logistical requirements.** See Table 3-12 for barbed wire and picket requirements and Table 3-13 for truck capacity for carrying mines.

STANDARD OBSTACLE MFJ (CONVENTIONAL MINES)

| Density | .5 - .5 - .0 mines per meter of front | | | | |
|---|---|---|---|---|---|
| Type | J1 | J2 | J3 | J4 | J5 |
| Length (meters) | 100 | 200 | 300 | 400 | 500 |
| Numer of mines | | | | | |
| AT | 69 | 136 | 203 | 270 | 337 |
| APF | 69 | 136 | 203 | 270 | 337 |
| Man-hours (experienced) | 32 | 62 | 92 | 122 | 152 |
| Man-hours (inexperienced) | 48 | 93 | 138 | 183 | 228 |

STANDARD OBSTACLE MFK (CONVENTIONAL MINES)

| Density | 1 - 1 - 1 mines per meter of front | | | | |
|---|---|---|---|---|---|
| Type | K1 | K2 | K3 | K4 | K5 |
| Length (meters) | 100 | 200 | 300 | 400 | 500 |
| Numer of mines | | | | | |
| AT | 124 | 246 | 368 | 490 | 612 |
| APF | 124 | 246 | 368 | 490 | 612 |
| APB | 124 | 246 | 368 | 490 | 612 |
| Man-hours (experienced) | 66 | 130 | 194 | 258 | 322 |
| Man-hours (inexperienced) | 99 | 195 | 291 | 387 | 483 |

NOTES: For MFJ and MFK standard obstacle minefields
1. Minefield is laid in a standard pattern with an irregular outer edge.
2. Minefield depth is 100 meters.

**Table 3-12.** Barbed wire and picket requirements for standard pattern minefields

| FRONT | BARBED WIRE METERS[1] | PICKETS[2] | SIGNS[3] |
|---|---|---|---|
| 100 | 1.568 | 53 | 16.79 |
| 200 | 2.128 | 71 | 22.107 |
| 300 | 2.688 | 90 | 27.134 |
| 400 | 3.248 | 109 | 33.162 |
| 500 | 3.808 | 127 | 39.191 |

NOTES: 1. Quantities are based on 100 meters of depth.
3. Based on 15-meter spacing.
4. Based on a 10- to 50-meter spacing.

**Table 3-13.** Truck capacity for carrying mines

| VEHICLE | M15 | M19 | M21 | M24 | M14 | M16A1/A2 | M18A1 |
|---|---|---|---|---|---|---|---|
| 2½-ton cargo | 102 | 69 | 55 | 90 | 113 | 111 | 94 |
| 5-ton dump | 204 | 138 | 111 | 150 | 216 | 222 | 188 |
| 5-ton cargo | 204 | 138 | 111 | 180 | 227 | 223 | 150 |
| 1½-ton trailer | 61 | 41 | 33 | 50 | 68 | 66 | 54 |
| Mines per case | 1 | 4 | 4 | 2 | 90 | 4 (each type) | 6 |

THIS PAGE INTENTIONALLY LEFT BLANK

**Recording** The Department of the Army (DA) Form 1355 is used to record all conventional minefields except hasty protective minefields (Figures 3-32 through 3-37).

# MINEFIELD - RECORD

(3) Copy No. 1 of 1
Sheet No. 1 of 1

(1) AUTHORITY: CG, 4th ARMD CAV DIV
LAYING UNIT: 2nd PLT, CoA, 6th ENGR BN
OFFICER IN CHARGE: ROY K WHITNEY, ILT 791-20-7762

(2) DATE AND TIME
START: 230500Z MAR 74
COMPLETION: 231800Z MAR 74
RECORDER: JOHN E GILLEY, SGT 692-12-6612

(4) MINEFIELD NUMBER: 4XX (AC) - 1 - E
(5) MAP: SERIES, NO. AND SCALE 1:50,000
SHEET NO (OR NAME) L II N6721

(6) LANDMARKS

| NO | COORDINATES | DESCRIPTION |
|---|---|---|
| 1 | UT 22008800 | NE CORNER OF ROAD JUNCTION, 1 U-SHAPE |
| 2 | UT 22038761 | PICKET DRIVEN FLUSH WITH GROUND |
| 3 | | NE CORNER OF BRICK BUILDING |
| 4 | | |

(7) INTERMEDIATE MARKERS

| NO. | DESCRIPTION |
|---|---|
| 1 | 3 SHORT U-SHAPE PICKETS WITH 12" LEFT ABOVE |
| 2 | GROUND WRAPPED WITH BARBED WIRE |
| 3 | |
| 4 | |

(8) DESCRIPTION OF BOUNDARY FENCE OR MARKING
STANDARD MARKING FENCE (2 STRAND) 3 SIDE OF MINEFIELD, ONLY ENEMY SIDE LEFT OPEN

(9) NO. OF STRIPS/~~ROWS~~ 4 DESCRIPTION OF STRIP ROW MARKERS
2"x2" WOODEN STAKE, WITH 8 PENNY NAIL DRIVEN FLUSH W/GROUND

(10) LANES

| NO. | WIDTH | HOW MARKED | METHOD OF CLOSING |
|---|---|---|---|
| 1 | 3M | WD 1 WIRE ON ℄ | AT APF, APB MINES |
| 2 | | 2 U-SHAPED PICKETS | STORED AT LANDMARK # 2 |
| 3 | | ENTRANCE / EXIT | |

(11) MINES

| TACTICAL MINEFIELD ~~NUISANCE MINEFIELD~~ ~~PICKET MINEFIELD~~ | | ANTITANK MINES (AT) TYPE M15 NO | TYPE NO | TYPE NO | TYPE NO | TYPE NO | TYPE NO | TOTAL AT MINES NO | ANTI-LIFT DEV NO | ANTIPERSONNEL MINES (AP) TYPE M16 NO | TYPE M14 NO | TYPE NO | TOTAL AP MINES NO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BURIED AND ~~SURFACE LAID~~ | IOE | 34 | | | | | | 34 | 10 | 68 | 68 | | 136 |
| | A | 93 | | | | | | 93 | 4 | 186 | 186 | | 372 |
| | B | 86 | | | | | | 86 | 3 | 172 | 172 | | 344 |
| | C | 86 | | | | | | 86 | 3 | 172 | 86 | | 258 |
| | D | 0 | | | | | | 0 | 0 | 267 | 89 | | 356 |
| IN STRIPS ~~IN ROWS~~ ~~IN PATTERN~~ | E | | | | | | | | | | | | |
| | F | | | | | | | | | | | | |
| | G | | | | | | | | | | | | |
| | H | | | | | | | | | | | | |
| | J | | | | | | | | | | | | |
| TOTAL | | 299 | | | | | | 299 | 20 | 865 | 601 | | 1466 |

(12) NOTES

TACTICAL

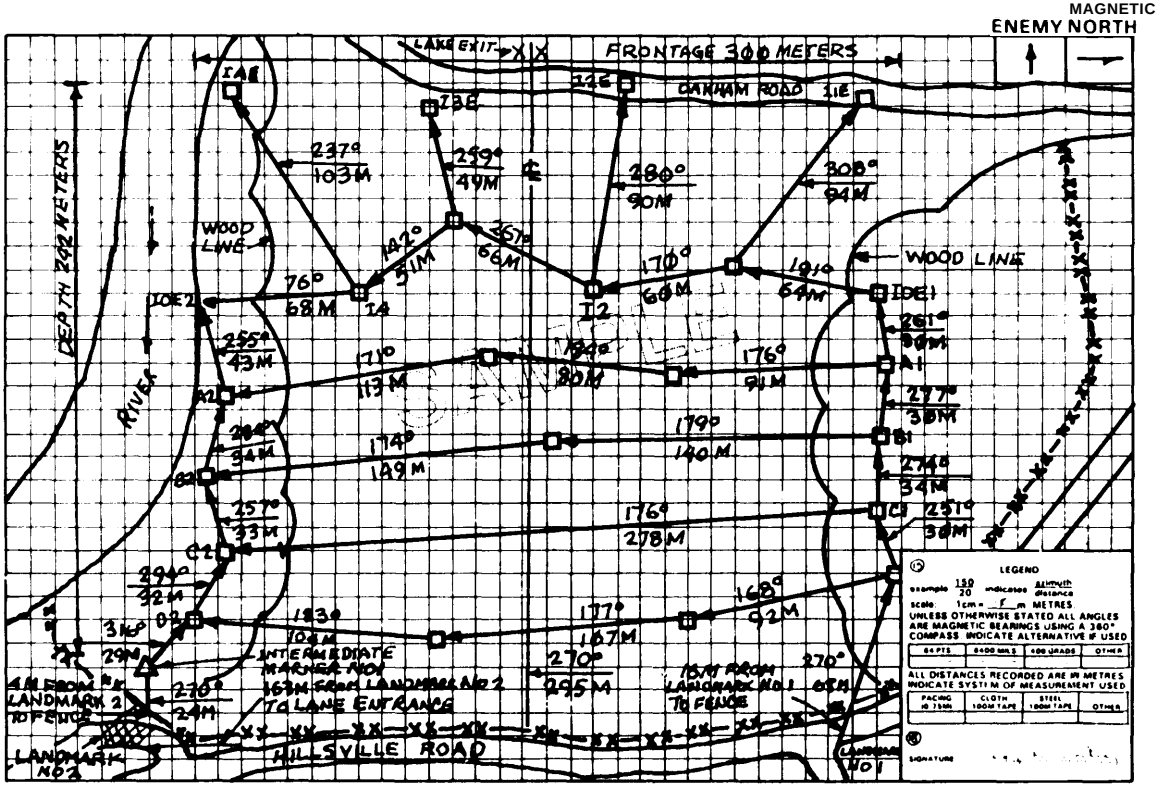
1. MINE CLUSTERS AT 3 METRES/~~PACES~~ SPACING

2. IOE LIVE CLUSTERS (All others are numbered but omitted) I1-1,4,10,15,18,24,27,28,29,30, I2-3,5,8,13,19,22,26,27, 28,29, I3-2,7,11,16, I4-1,3,4,8,11,14,21,25,30,33 3. Numbered omitted clusters: a) LANE IOE-NONE, A-57,58,59,60,61, B-46, 47,48,49,50, C-47,48,49,50, D 49,50,51,52,53, (b) A-1-5-TREES B-90-TREE, C-87-ROCK, D-90-CONC SLAB 4 AND IOE I1-27, 28,29,30, I2-19,27,28,29, I3-16, I4-21, A-12,21,56,85, B-10,35,78, C-25,36,70, D-NONE 5 TRIPWIRE A-11,21,57, 83, B-11,35,67,81, C-3,9,15,21,27,33,55,61,85,91 6 STRIP CLUSTER COMP 7 SAFETY CUPS 30 CM REAR OF C/STRIP MARKER

SIGNATURE (OFFICER IN CHARGE) ILT Roy K Whitney
DATE: 23 MAR 74 (13)

DA Form 1355

Figure 3-32. Standard detailed minefield record (DA Form 1355) (front)




DA Form 1355

Figure 3-33. Standard detailed minefield record (DA Form 1355) (back)

# MINEFIELD - RECORD

(3) Copy No 1 of 1
Sheet No 1 of 1

(1) AUTHORITY: CG 19TH U S ARMY CORPS
LAYING UNIT: 3RD PLT Co A, 92ND ENGR BN
OFFICER IN CHARGE: 2LT WILL J. RUTLEDGE 792-22-6394

(2) DATE AND TIME
START: 130645Z MAR 75
COMPLETION: 131755Z MAR 75
RECORDER: RONALD CORPOS, SGT 601-22-1246

(4) MINEFIELD NUMBER: 19XXX-59-E
(5) MAP: SERIES, NO AND SCALE 1 50,000
SHEET NO (OR NAME) 7739

(6) LANDMARKS

| NO | COORDINATES | DESCRIPTION |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |

(7) INTERMEDIATE MARKERS

| NO | DESCRIPTION |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |

(8) DESCRIPTION OF BOUNDARY FENCE OR MARKING

(9) NO OF STRIPS/ROWS: DESCRIPTION OF STRIP ROW MARKERS

(10) LANES

| NO. | WIDTH | HOW MARKED | METHOD OF CLOSING |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |

(11) TACTICAL MINEFIELD ~~BUILDING MINEFIELD~~ ~~PHONEY MINEFIELD~~

| MINES | | ANTITANK MINES (AT) TYPE M19 NO | TYPE NO | TYPE NO | TYPE NO | TYPE NO | TYPE NO | TOTAL AT MINES NO | ANTI-LIFT DEV NO | ANTIPERSONNEL MINES (AP) TYPE M16 NO | TYPE M14 NO | TYPE NO | TOTAL AP MINES NO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BURIED AND SURFACE LAID | IDE | | | | | | | | | | | | |
| | A | 24 | | | | | | 24 | 24 | 15 | 47 | | 62 |
| | B | 17 | | | | | | 17 | 17 | 40 | 52 | | 92 |
| | C | 21 | | | | | | 21 | 21 | 32 | 18 | | 50 |
| | D | Ø | | | | | | Ø | Ø | Ø | Ø | | Ø |
| ~~IN STRIPS~~ ~~IN ROWS~~ W O PATTERN | E | | | | | | | | | | | | |
| | F | | | | | | | | | | | | |
| | G | | | | | | | | | | | | |
| | H | | | | | | | | | | | | |
| | J | | | | | | | | | | | | |
| TOTAL | | 62 | | | | | | 62 | 62 | 87 | 117 | | 204 |

(12) NOTES

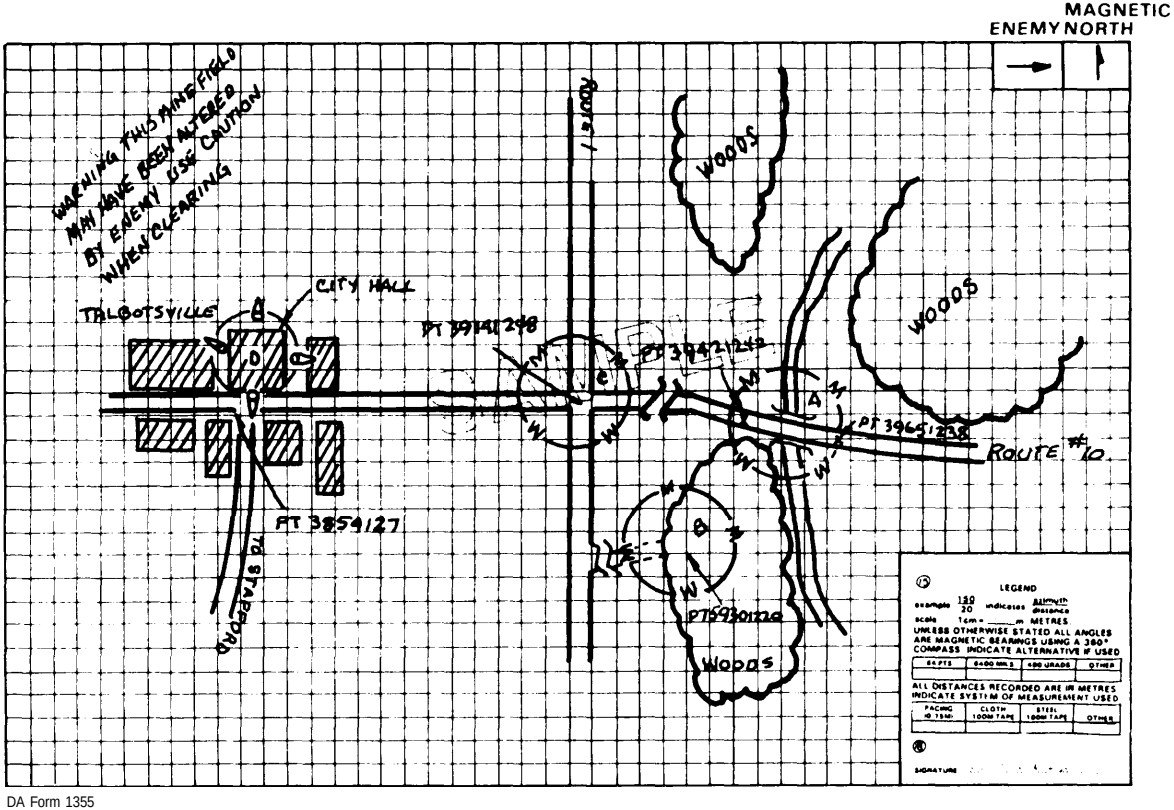
1. ~~MINE CLUSTERS AT~~ MINES ARE LAID WITHOUT PATTERN AROUND KEY POINTS ~~METRES/PACES SPACING~~ AND MARKED BY RIGHT DIGIT GRID
2. MINES EQUIPPED W/ANDS: GROUP A: (AROUND BRIDGE) 24 M19 MINES W/M5 DEVICE (BOTTOM); GROUP B: (ENTRANCE TO WOODS) 17 M19 MINES W/M5 DEVICE (BOTTOM); GROUP C: (ROAD JUNCTION) 21 M19 MINES W/M1 DEVICE (SIDE); GROUP D: (CITY HALL) NONE
3. MINES WITH TRIPWIRE (M16 ONLY) - GROUP A 5; GROUP B: 10; GROUP C: 8; GROUP D. NONE 4. IMPROVISED MINES: GROUP A, B C NONE; D - 5 lbs C 4 UNDER MAYORS DESK (ACTIVATE ELECTRICALLY BY BUZZER / NON ELEC BY M1 PULL DEVICE TO CHAIR 5. ALL SAFETY CLIPS BURIED UNDER CITY HALL FRONT STEPS 6. TEMPORARY MARKERS REMOVED 132200 75

SIGNATURE (OFFICER IN CHARGE) 2LT Will J. Rutledge
DATE: 13 MAR 75

(13)

DA Form 1355

Figure 3-34. Record of point minefield with minimum information (DA Form 1355) (front)




DA Form 1355

Figure 3-35. Record of point minefield with minimum information (DA Form 1355) (back)

# MINEFIELD - RECORD

(3) Copy No 1 of 1
Sheet No 1 of 1

(1) AUTHORITY CG, 8xx (INF)
LAYING UNIT 3rd PLT, Co A, 54th ENGR BN
OFFICER IN CHARGE Jerry D Williams, 2LT 234-79-2220

(2) DATE AND TIME
START 071100Z MAR 75
COMPLETION 072000Z MAR 75
RECORDER MARK B DAVIS, SGT 792 77-2269

(4) MINEFIELD NUMBER 8xx (INF) 1 E
(5) MAP SERIES NO. AND SCALE 1:50 000
SHEET NO (OR NAME) 721/TALBOTVILLE

(6) LANDMARKS

| NO | COORDINATES | DESCRIPTION |
|---|---|---|
| 1 | UT 8260 7770 | BRICK CHURCH BUILDING N.W CORNER |
| 2 | UT 7820 7771 | EAST SIDE ROAD INTERSECTION |
| 3 | | |
| 4 | | |

(7) REFERENCE ~~INTERMEDIATE MARKERS~~ STAKE.

| NO | DESCRIPTION |
|---|---|
| 1 | U-SHAPED PICKET X-LONG, 5 WRAPS ENGR TAPE |
| 2 | |
| 3 | |
| 4 | |

(8) DESCRIPTION OF BOUNDARY FENCE OR MARKING

(9) NO ~~OF STRIPS/~~ROWS 4 DESCRIPTION OF STRIP ROW MARKERS

(10) LANES

| NO | WIDTH | HOW MARKED | METHOD OF CLOSING |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |

(11) TACTICAL MINEFIELD ~~NUISANCE MINEFIELD~~ ~~PICKET MINEFIELD~~

| MINES | | ANTITANK MINES (AT) TYPE | TYPE | TYPE | TYPE | TYPE | TYPE | TOTAL AT MINES | ANTI LIFT DEV | ANTIPERSONNEL MINES (AP) TYPE | TYPE | TYPE | TOTAL AP MINES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MIN | | | | | | | | | | | |
| | | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| ~~BURIED~~ AND ~~SURFACE LAID~~ UNDERWATER | ID | | | | | | | | | | | | |
| | A | 7 | | | | | | 7 | | | | | |
| | B | 7 | | | | | | 7 | | | | | |
| | C | 7 | | | | | | 7 | | | | | |
| | D | 7 | | | | | | 7 | | | | | |
| ~~IN STRIPS~~ IN ROWS ~~IN PATTERN~~ | E | | | | | | | | | | | | |
| | F | | | | | | | | | | | | |
| | G | | | | | | | | | | | | |
| | H | | | | | | | | | | | | |
| | J | | | | | | | | | | | | |
| TOTAL | | 28 | | | | | | 28 | | | | | |

(12) NOTES

POINT

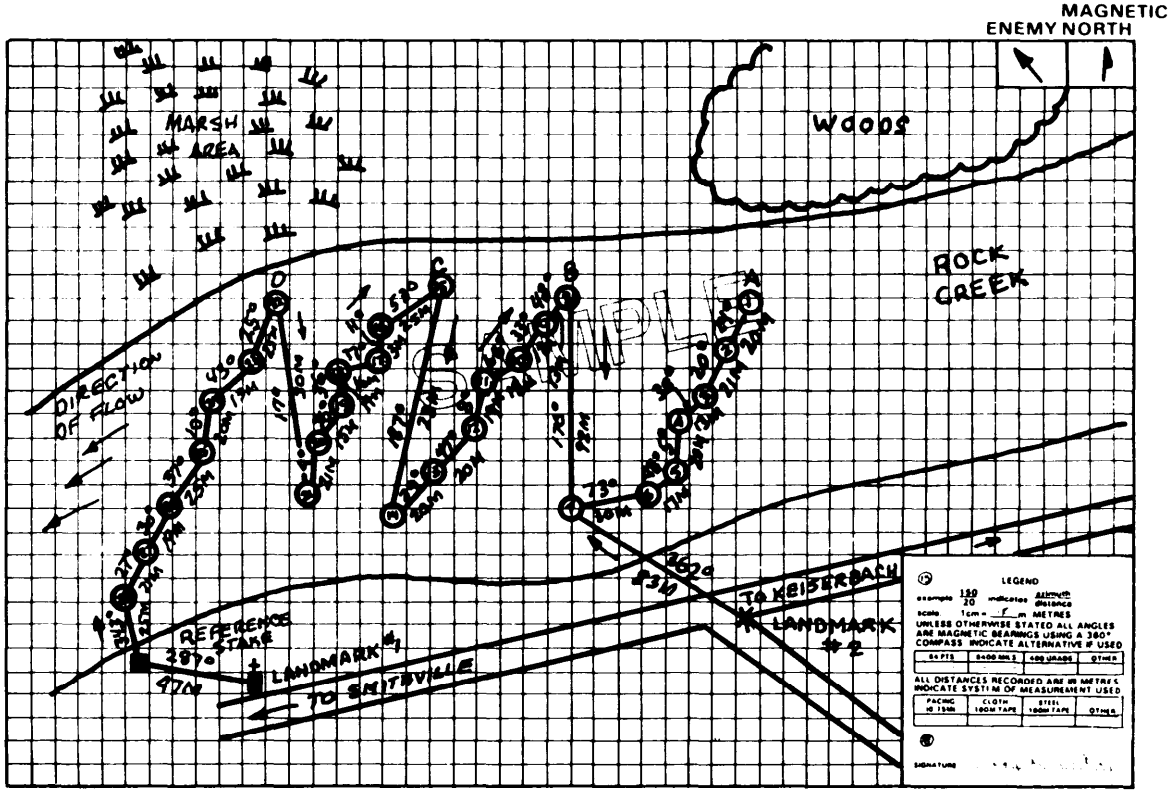
1. MINES ARE LAID IN VARIOUS METRE INTERVALS ~~MINE CLUSTERS AT METRES/PACES SPACING~~
2. All MINES EQUIPPED WITH OUTRIGGERS (HOLD DOWN DEVICE)
3. All MINES WATER RESISTANT TREATED
4. All SAFETIES CLIPS BURIED 1/3 METER SOUTH OF REFERENCE STAKE
5. AVERAGE DEPTH OF STREAM IS ONE METER
6. ARROWS SHOW DIRECTION AZIMUTHS WERE TAKEN
7. MINES ARE NUMBERED IN SEQUENCE AS THEY ARE INSTALLED
8. OMITTED CLUSTERS NONE

SIGNATURE (OFFICER IN CHARGE) 2LT Jerry D. Williams
DATE 07 MAR 75

(13)

DA Form 1355

Figure 3-36. Record of mines emplaced in ford deeper than 0.6 meter (front)




DA Form 1355

Figure 3-37 Record of mines emplaced in ford deeper than 0.6 meter (back)

## Minefield markings

**Marking sets.** The hand emplaced minefield marking set (HEMMS) is capable of marking 700 to 1,000 meters and is normally used for temporary marking The US No. 2 minefield marking set is capable of marking 400 meters per set and is used to replace HEMMS if the minefield is to be left in place for more than 15 days.

**Marking procedures.** Minefields are normally marked to prevent friendly personnel from accidentally entering the minefield. Figures 3-38 through 3-40 represent typical markings and marked minefield perimeters and lanes. Scatterable minefields will be marked to the maximum extent possible to protect friendly troops. The same marking procedures for conventional minefield will be used. Marking requirements are shown in Table 3-15 (page 3-37)

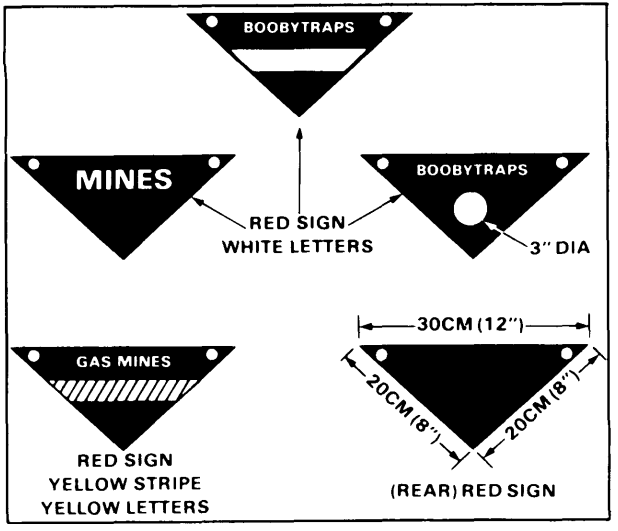



Figure 3-38. Standard marking signs

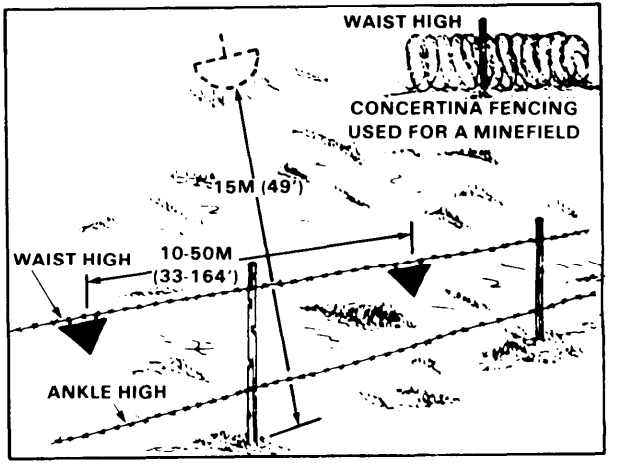



Figure 3-39. Minefield marking fence

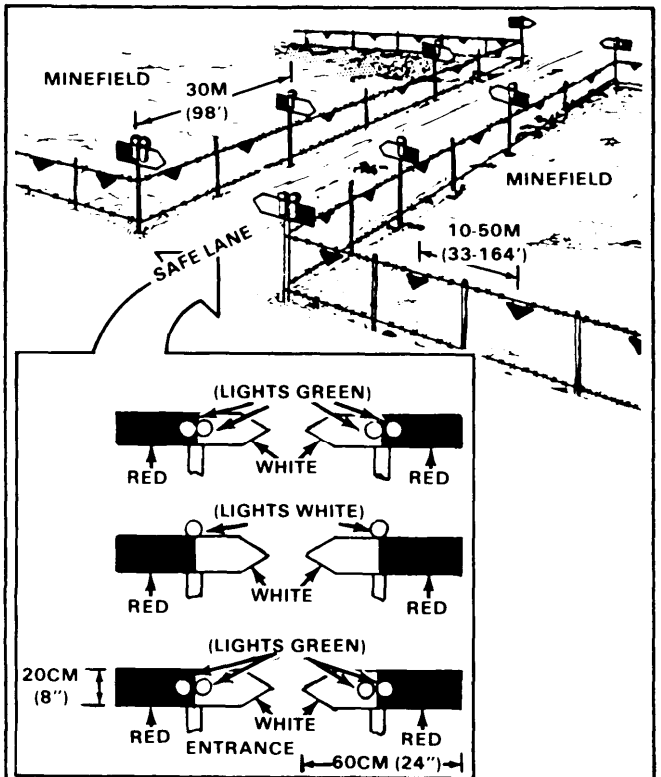



Figure 3-40. Standard lane markings

## Scatterable Minefields

**Standard scatterable minefield**

STANDARD OBSTACLE MFG (GEMSS SCATTERABLE MINES)

| | | | | | | |
|---|---|---|---|---|---|---|
| ANTITANK | MFGT | | | | | |
| ANTIPERSONNEL | MFGP | | | | | |
| MIXED | MFGM | | | | | |
| Width 60 meters | | | | | | |
| Lenqth (meters) (If every mine of a maximurn 800 mine load is dispensed.) NOTE: Length of minefield may be doubled when a width of 30 meters is used. | | 13,333 | 2,666 | 1,904 | 1,333 | 533 |
| Density (mines/M$^2$) | | .001 | 005 | .007 | .01 | .025 |
| Effort (squad hours) | | 2.24 | .45 | 32 | .22 | .09 |

STANDARD OBSTACLE MFH (M56 SCATTERABLE MINES)

| | | |
|---|---|---|
| Width 20 meters | | |
| Length (meters) | 1,600 | 800 |
| Area density (mines/M$^2$) | .005 | .01 |
| Linear density (mines/M) | . 1 | . 2 |
| Time | 1 to 3 minutes | |

STANDARD OBSTACLE MFAF (GATOR SCATTERABLE MINES)

1 Area of minefield is dependent upon the speed and altitude of the aircraft Normal size is 650 x 200 meters.
2 Density is dependent upon the number of canisters that are dropped As the system is used primarily for interdiction minefields, somewhat lower than normal densities (0.001 mines/$M^2$) are normally planned.
3 Each canister (bomblet)contains 72AT and 22 AP mines Up to six canisters may be mounted on each aircraft.

STANDARD OBSTACLE MFM (MOPMS SCATTERABLE MINES)

| Area | Number of Mines | Density (Mines/$M^2$ |
|---|---|---|
| Semicircle, 35-meter radius | 21 | .01 |

STANDARD OBSTACLE MFA (ADAM RAAMS SCATTERABLE MINES)

**Aiming points**

Table 3-14 Estimated aiming points

| DELIVERY TECHNIQUE | DESIRED MINEFIELD WIDTH (METERS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1,000 |
| RAAMS Low Angle<br>Met + VE<br>Observer adj | 3<br>2 | 4<br>3 | 4<br>3 | 5<br>4 | 5<br>4 | 6<br>5 | 6<br>5 | 7<br>6 | 7<br>6 | 8<br>7 |
| RAAMS High Angle<br>Met + VE<br>Observer adj | 2<br>1 | 2<br>1 | 2<br>1 | 3<br>2 | 3<br>2 | 3<br>2 | 3<br>2 | 4<br>3 | 4<br>3 | 4<br>3 |
| ADAM Low/High Angle<br>Met + VE<br>Observer adj | 2<br>1 | 2<br>1 | 2<br>1 | 3<br>2 | 3<br>2 | 3<br>2 | 3<br>2 | 4<br>3 | 4<br>3 | 4<br>3 |

NOTES: 1. Chart based on 12,000-meter range
2. Depth RAAMS 400 meters (high angle)
RAAMS 200 meters (low angle)
ADAM 400 meters (high/low angle)
3. BMA - less than or equal to 800 Mil
See FM 6-20 for exact aiming point requirements.

MFAT
RAAMS (high angle)
400 x 400 merers coverage

| Purpose | Area Density | Number of Rounds Per Aim Point |
|---|---|---|
| Harass enemy | .001 | 24 |
| Covered by heavy, direct fire | .002 | 48 |
| Covered by light, direct fire | .004 | 96 |

MFAT

RAAMS (low angle)

200 x 200 meters coverage

| Purpose | Area Density | Number of Rounds Per Aim Point |
|---|---|---|
| Harass enemy | .001 | 6 |
| Covered by heavy, direct fire | .002 | 12 |
| Covered by light, direct fire | .004 | 24 |

MFAP
ADAM
400 x 400 meters coverage

| Purpose | Area Density | Number of Rounds Per Aim Point |
|---|---|---|
| Harass enemy | .0005 | 3 |
| Covered by heavy, direct fire | .001 | 6 |
| Covered by light, direct fire | .002 | 12 |

Recording

| LINE # | INFORMATION REQUIRED | DATA - INST ON BACK (EXAMPLE) |
|---|---|---|
| 1 | APPROVING AUTHORITY | 2BDE3AD |
| 2 | TGT/OBSTACLE # | NA |
| 3 | TYPE EMPLACING SYSTEM | GEMSS |
| 4 | TYPE MINES | AT/AP |
| 5 | SELF-DESTRUCT PERIOD | 101630Z-102130ZOCT82 |
| 6 | AIM PT/CORNER PTS OF MINEFIELD [1] | MB 17955490 |
| 7 | | MB 18604860 |
| 8 | | MB 18504890 |
| 9 | | MB 18054895 |
| 10 | | MB 17804850 |
| 15 | SIZE SAFETY ZONE FROM AIM PT [2] | NA |
| 16 | UNIT EMPLACING MINES/ RPT# | BC023ENGR/4 |
| 17 | PERSON COMPLETING RPT | 1LT JENNINGS |
| 18 | DTG OF REPORT | 051400ZOCT82 |
| 19 | REMARKS | MINEFIELD AROUND TANK DITCH |

NOTES: 1. If the system used to emplace the minefield uses a single aim point to deliver the mines, enter that aim point MB 10102935. If the system has distinct corner points such as GEMSS, enter those corner points MB 17954790, MB 18604860, MB 18504890, MB 18054895, MB 17804850.

2. If an aim point is given in Line 6, enter the size safety zone from that aim point. Example: Artillery emplaces a minefield from aim point MB 10102935 and the safety zone is 1,000M x 1,000M, enter 500M so that personnel plotting or receiving the information can plot the coordinate and go 500M in each direction from the aim point and plot the safety zone.

Figure 3-41. Scatterable minefield report and record, with example

Marking

Table 3-15. Scatterable minefield marking requirements

| MINEFIELD LOCATION | | MARKING REQUIRED (NOTE) |
|---|---|---|
| ENEMY AREAS | | NONE |
| Friendly areas | Forward of FEBA | Both sides and rear |
| | Rear of FEBA | All sides |

NOTE: Ground emplaced mines - mark prior to laying
Air emplaced mines - not marked

**US Mines and Fuzes**
See Table 3-16 through 3-18

Table 3-16. US antipersonnel mines

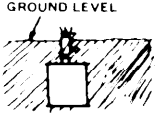
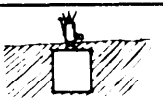
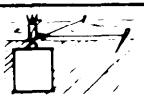
| MINE | PACKING | ARMING PROCEDURES | | | DISARMING |
|---|---|---|---|---|---|
| M14 Blast Antipersonnel Mine<br> <br>Wt ..... 3 1/3 oz<br>Explosive ..... 1 oz TETRYL<br>Fuze ..... integral (with Belleville Spring)<br>Functioning 20 to 35 lb<br>Penetrate Boot and Foot | Carton contains<br>90 mines<br>90 detonators<br>6 or 9 wrenches<br><br>Dimensions (cm/in)<br>Length 50/20<br>Width 44/17<br>Height 22/9<br>Total Wt 46 lb<br>21 Kg | <br>Unscrew shipping plug from bottom of mine. Turn pressure plate to ARMED position with arming tool. | <br>Remove safety clip and check for malfunctioning. | <br>Replace safety clip. | TO DISARM: Insert safety clip and remove detonator. |
| | | <br>Screw detonator into detonator well. | <br>Bury mine and remove safety clip. | CAUTION: Repeated turning of arming dial may cause excessive wear.<br><br>TO BURY: Pressure plate should be slightly above ground level. | |
| M16A1 Bounding Antipersonnel Mines<br> <br>Wt ..... 8.25 lb<br>Projectiles ..... steel<br>Fuze ..... M605 (Combination)<br>Functioning<br>Pressure ..... 8 to 20 lb<br>Pull ..... 3 to 10 lb<br>Bounding Height ..... 6-1.2m<br>Casualty Radius ..... 30m | Wooden Box<br>4 mines per box<br>4 fuzes per box<br>1 arming wrench<br>4 tripwires<br><br>Dimensions (cm/in)<br>Length 41/16<br>Width 28/11<br>Height 22/9<br>Total Wt 45 lb<br>20 Kg | <br>Remove shipping plug and screw in fuze. | GROUND LEVEL<br>  <br>Pressure installation |  <br>Tripwire installation | TO DISARM: Reverse arming procedure. |
| | |  <br>Attach tripwires—first to anchor, then to pull ring. | <br>Remove locking safety pin first. The interlocking pins should fall free. Then remove positive safety. | M16A2 is similar to M16A1/M16 but fuze well is not centered on mine. | |

Table 3-16. US antipersonnel mines (continued)

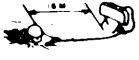
| MINE | PACKING | ARMING PROCEDURES | | | DISARMING |
|---|---|---|---|---|---|
| **M18A1 Fragmentation Antipersonnel Mine**<br> <br>Wt 3.5 lb<br>Explosive 1.5 lb C4<br>Projectiles 700 (steel balls)<br>Equipment: One electric cap 30m firing wire per mine. One electric firing device per mine. One tester per 6 mines. | **Wooden Box**<br>6 mines with accessories.<br><br>Dimensions (in)<br>Length 20<br>Width 11.5<br>Height 9.75<br>Total Wt 33 lb | <br>**TEST CIRCUIT** Mate firing device, circuit tester, and blasting cap. Depress handle. Light should show in window. Separate test components. | **AIMING** In aiming the M18A1, when using the slit type peep sight, aim the mine at an individual's head when standing 45m from the mine. When using the knife edge sight, aim the mine at an individual's feet when standing 50m from the mine. | <br>Remove shipping plug, priming adapter, insert blasting cap and screw into either cap well. | **TO DISARM** Reverse arming procedure. |
| | |  <br>Unroll firing wire and connect directly to firing device with safety engaged. | <br><br>**FIRING POSITION** A minimum of 16 meters from rear of mine to fighting position. Friendly troops at side and rear should be under cover at a minimum of 100 meters. | **TO FIRE** Disengage safety bail and depress handle. | |

Table 3-17. US antitank mines

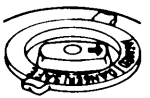
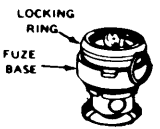
| MINE | PACKING | ARMING PROCEDURES | | | DISARMING |
|---|---|---|---|---|---|
| M15 Heavy Antitank Mines<br> <br>Wt ..... 30 lb<br>Explosive ..... 22 lb<br>Fuze ..... M603<br>Secondary fuze wells ..... 2<br>Functioning:<br>300 to 400 lb | Individual crate<br>1 mine with fuze<br>1 activator<br><br>Dimensions: (in)<br>Length: 18<br>Width: 15.3<br>Height: 7.5<br>Total Wt: 49 lb | <br>Remove plug and inspect fuze well. | <br>Inspect fuze and remove safety. | <br>Insert fuze. | TO DISARM: Reverse arming procedure. |
| | | <br>Replace plug with dial in safe position. |  <br>Turn dial to ARMED. | TO BURY: Put mine in hole with pressure plate at or slightly above ground level. | |
| M15 Antitank Mine used with M608 Fuze<br> <br>Functioning ..... 200-350 lb for 250-450 milliseconds.<br>Resistant to blast type countermeasures. | Same as above. |  <br>Remove plug and inspect fuze well. Ensure fuze is in SAFE position. Thread fuze into mine...HAND TIGHT.<br>Hold fuze to prevent rotating, turn locking ring down until it locks against pressure plate. | <br>Place mine in hole and remove pull pin from fuze. | <br>Turn dial from SAFE to ARMED. | TO DISARM: Reverse procedure except DO NOT replace pull pin. |

Table 3-17. US antitank mines (continued)

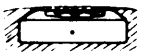
| MINE | PACKING | ARMING PROCEDURES | | | DISARMING |
|---|---|---|---|---|---|
| M19 Plastic Heavy Antitank Mine<br> <br>Wt 28 lb<br>Explosive 21 lb<br>Fuze M606 integral (with pressure plate)<br>Secondary fuze wells 2<br>Functioning 350 to 500 lb | Wooden Box<br>2 mines<br>2 fuzes<br>1 arming wrench<br><br>Dimensions (in)<br>Length 16.8<br>Width 10.8<br>Height 16<br>Total Wt 71.8 lb | <br>Remove pressure-plate fuze | <br>Remove shipping plug, check position of striker (offset). Remove safety fork, then turn dial to ARMED position. Check position of striker (center). Turn to SAFE and replace safety fork. | <br>Screw threaded detonator into detonator well | TO DISARM: Reverse arming position |
| | | <br>Place mine in hole, remove safety fork, and turn dial to ARMED |  <br>Complete camouflage. | TO BURY: Put mine in hole with pressure plate at or slightly above ground level | |

Table 3-17. US antitank mines (continued)

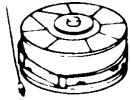
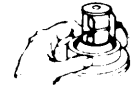
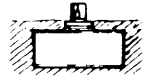
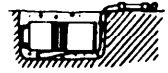
| MINE | PACKING | ARMING PROCEDURES | | | DISARMING |
|---|---|---|---|---|---|
| M21 Metallic (Killer) Antitank Mine<br>  <br>Wt ..... 18 lb<br>Explosive ..... 10.5 lb<br>Fuze ..... M607<br>Functioning ..... 290 lb<br>(Pressure or pressure ring or 20° deflection of tilt rod) | Wooden Box<br>4 mines<br>2 wrenches<br><br>Dimensions (in)<br>Length 22.2<br>Width 20.2<br>Height 16<br>Total Wt 90.8 lb | <br>Remove closing plug, insert M120 booster in bottom, and replace closing plug. | <br>Remove closure assembly from fuze. |  <br>Remove shipping plug from mine and screw in fuze, then screw in tilt rod extension. | TO DISARM: Reverse arming procedure. |
| | |  <br>Bury mine. | <br>Remove safety (pull ring assembly) and complete camouflage. | For pressure type mine bury with fuze cap flush with ground surface. Tilt rod-mines should be seated firmly in snug-fitting hole. Most effective in tall brush or grass. | |
| M23 and M1<br>1 Gallon Chemical Landmines<br> <br> <br><br>Wt 11 lb loaded, has a 1.2m length of detonating cord for burster charge. May be armed for electric or tripwire actuation. | Uncrated | WARNING: Soldiers preparing, laying, and removing chemical landmines must wear protective clothing. | When armed for pressure detonation, emplace in same manner as the M15 antitank mine. | <br>Bury mine 10cm and attach detonating cord to controlled firing system. | If armed for pressure, see warning and disarm as M15. If armed electrically or nonelectrically, disable firing circuit IAW appropriate procedure for specific system. |
| | | Nonelectric Firing<br>  <br>Bury mine as above and attach nonelectric detonator to burster. | Electric Firing<br> <br>Attach burster charge (1.2m length of detonating cord) to side of mine. | | |

Table 3-17. US antitank mines (continued)

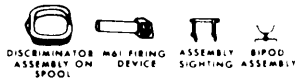
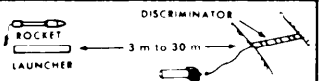
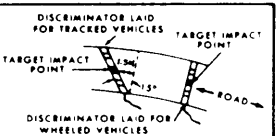
| MINE | PACKING | ARMING PROCEDURES | DISARMING |
|---|---|---|---|
| M24 Off-Route Antitank Mine<br><br>Dispenser Pouch<br> <br>Accessories Pouch | Wooden Box<br>4 mines<br><br>Dimensions (in)<br>Length: 28.1<br>Width: 13.9<br>Height: 10.8<br>Total Wt: 55 lb |  <br>Remove above items from accessories pouch. Insert batteries (issued separately) in firing device.<br><br> <br>Attach discriminator wire to DETECTOR of firing device (toggle switch on SAFE). Stand on two brown marks on discriminator nearest firing device. If lamp lights, circuit is good, otherwise, discard system.<br><br>  <br>Disconnect discriminator wire from firing device. Remove launcher from dispenser pouch and place in position. Remove packing blocks, push rocket forward to safety band, and remove band. Depress ejection pin and push rocket back into launcher until contact ring is exposed at base. Grounding clip must be connected. Remove tagged shorting clip and push rocket back into launcher. Tape plastic covers over ends of launcher.<br><br>  <br>Unreel discriminator starting at far side of road (perpendicular to edge for wheeled vehicles; about 15° from perpendicular for tracked vehicles).<br><br> <br>Position launcher on bipod assembly or mound of earth. Mount sighting assembly and sight along discriminator to target impact point about 1m above road (soldier's belt buckle.) To aim, move launcher, not sight. Fill poucher with dirt, lay over launcher, recheck sight, remove sight, reconnect discriminator wire to firing device (light out), connect rocket cable to firing device, and push toggle switch to ARM. The system is now armed and will fire when pressure is applied to the discriminator. See TM 9-1345-200. | Reverse arming procedures |

Table 3-18. Firing devices and trip flare

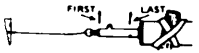
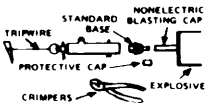
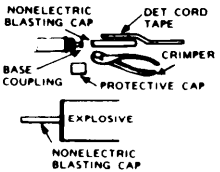
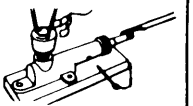
| TYPE | ARMING PROCEDURES | | | DISARMING |
|---|---|---|---|---|
| **M1**<br>Pull Firing Device<br> <br><br>Initiating action: 3 to 5 lb pull on tripwire. |  <br><br>**TO ARM**: Remove locking safety pin first and position safety pin last. |  <br><br>Remove protective cap from standard base and crimp on nonelectric blasting cap. Attach firing device assembly in charge. Attach anchored tripwire. | <br>The M1 pull firing device can be used as an antihandling device on the M15 or M19 AT mines. The arming procedures are the same as above. The device is employed in the side fuze well and a tripwire attached from the M1 to a stake secured underground near the mine. | <br><br>**TO DISARM**: Insert nail, wire, or original safety pin in postive safety pin hole first. Then insert similar pin in locking safety pin hole. Cut tripwire, and separate fire device and explosive. Unscrew standard base. |
| **M1A1**<br>Pressure Firing Device<br> <br><br>Initiating pressure: 10 lb or more |  <br> | Remove protective cap from base and crimp on nonelectric blasting cap. Assemble detonating cord, nonelectric blasting cap, and firing device. | <br><br>**TO ARM**: Remove safety clip. Then positive safety pin. |  <br>**TO DISARM**: Insert wire, nail, or original pin in positive safety hole. Replace safety clip if available. Unscrew base assembly from firing device. |
| **M3** Pull-Release<br>Firing Device<br> <br> | <br>**TO ARM**: With cord, remove small cotter pin from locking safety pin, and withdraw locking safety pin. If it does not remove easily, adjust winch winding. With cord, pull out positive safety pin. | <br> | Remove protective cap and crimp on a nonelectric blasting cap. Attach firing device assembly to anchored charge (must be firm enough to withstand pull of at least 6-10 lb. pull on tripwire). Put free end of anchored tripwire in hole in winch with knurled knob, draw up tripwire until locking safety is pulled into wide part of safety pin hole. | **TO DISARM**: The M3 is dangerous to disarm. It should be blown in place.<br>**NOTE**: If the device must be disarmed, proceed as follows: Insert wire, nail, or original pin in positive safety pin hole first. Then insert wire, nail, or original locking pin in locking pin hole. Disassemble tripwire, firing device, and explosive. |

Table 3-18. Firing devices and trip flare (continued)

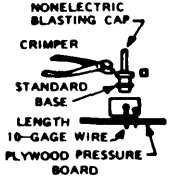
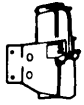
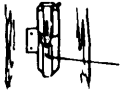
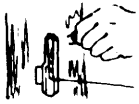
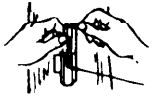
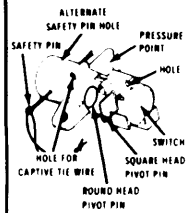
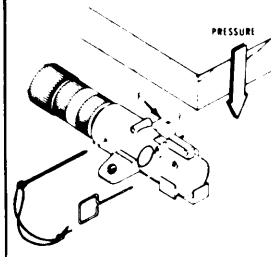
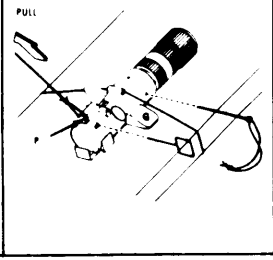
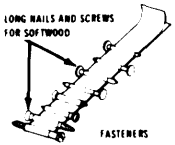
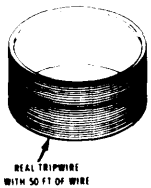
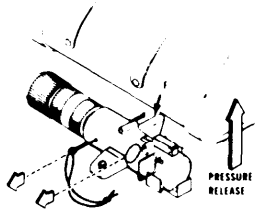
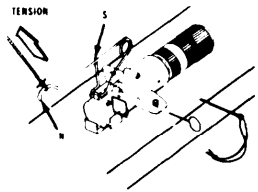
| TYPE | ARMING PROCEDURES | | | DISARMING |
|---|---|---|---|---|
| M5 Pressure-Release Firing Device<br> <br><br>Initiating action: Lifting 1.59cm or removing restraining weight (5 lb or more). |  <br> | Insert 10-gage wire in interceptor hole, hold release plate down, and remove safety pin. Replace safety pin with length of No. 18 wire. Assemble cap, firing device, and mine. | <br><br>TO ARM: Remove thin wire (locking safety) and then heavy wire (positive safety) from interceptor hole. FOLLOW ARMING PROCEDURES CAREFULLY. | <br><br>TO DISARM: Insert heavy gage wire in interceptor hole. Bend wire to prevent dropping out. Proceed carefully, as the slightest disturbance of restraining weight may detonate mine. Disassemble firing device and mine. |
| M49A1 Trip Flare<br>  <br>Burning period .....55 to 70 sec<br>Illumination radius..... 300m<br>Initiated by taut or loose tripwire. | WARNING: Never look directly at burning flare. Note: For loose tripwire initiation, attach tripwire to eye of safety pin.<br> <br>Attach flare to post or tree. |  <br>Attach tripwire to anchor, then to trigger. Pull trigger to vertical position and secure. |  <br>TO ARM: Remove safety clip. |  <br>TO DISARM: Insert safety pin.<br> <br>Check both ends of tripwire and cut near trigger. |

Table 3-18. Firing devices and trip flare (continued)

| TYPE | PACKING | ARMING PROCEDURES | | DISARMING |
|---|---|---|---|---|
| M142 Multipurpose Firing Device<br>  <br><br> <br> | Wooden Box<br>56 each<br>Dimensions (in)<br>Length 17 3<br>Width 11 78<br>Height 8 18<br>Total Wt 53 lb |  <br> | PRESSURE 25 lb or more to function<br>(1) Check safety pin for ease of removal and reinsert<br>(2) Secure switch in position with either nails, screws, or wire<br>(3) Screw in coupling base firing device F4<br>(4) Place a suitable pressure plate in position to rest on point F<br>Ensure plate is not heavy enough to activate the switch<br>(5) Remove pin with square head, using wire if necessary<br>(6) Withdraw safety pin, using wire if necessary<br>If safety pin resists movement, do not withdraw, recheck setting | STEPS<br>1 Determine mode of operation<br>2 Determine what fires the charge (blasting cap activator, or time fuze)<br>3 Proceed based on following table<br>4 Destroy in place or notify EOD<br>5 Cut time fuze<br>6 Insert nail, wire, or safety pin through positive safety hole<br>7 Insert round head pin (if not in place)<br>8 Insert square head pin (if not in place)<br>9 Ensure that positive safety pin, round head and square head pins are in place before continuing<br>10 If disarming on mine, place mine arming dial to SAFE<br>11 Cut tripwire or release pressure<br>12 Unscrew coupling base or standard base<br>13 Remove firer from charge<br>WARNING<br>DO NOT REMOVE BLASTING CAP FROM BASE<br>14 Restore mechanism to shipping configuration |
| | |  <br> | PULL 7 lb or more to function<br>(1) Check safety pin for ease of removal and reinsert<br>(2) Secure switch to a fixed object with nails, screws, or wire<br>(3) Screw in coupling base firing device F4<br>(4) Attach tripwire to hole P so that pull is in direction shown<br>(5) Remove pin with square head<br>(6) Withdraw safety pin from a safe distance using a wire if necessary<br>If safety pin resists movement, do not withdraw, recheck setting | |

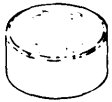
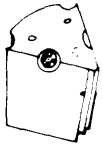
| FIRER | MODE | STEPS |
|---|---|---|
| Blasting cap or Activator | Tension release | 4 |
| Blasting cap or Activator | Pressure, pull<br>Pressure release | 6 thru 14 |
| Time fuze | All mode | 5 thru 14 |

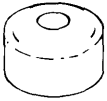
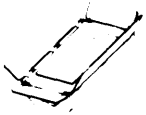
Table 3-18. Firing devices and trip flare (continued)

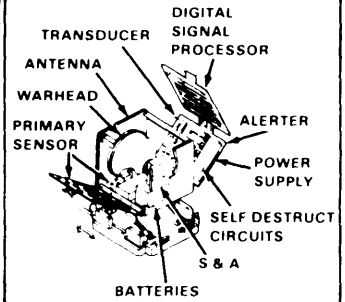
| TYPE | PACKING | ARMING PROCEDURES | | DISARMING |
|---|---|---|---|---|
| <br>  <br>  | |  | **PRESSURE RELEASE** - 2 lb or more to set but not more than 150 lb.<br>(1) Check safety pin for ease of removal and reinsert.<br>(2) Place switch in position and secure with either nails, screws, or wire.<br>(3) Screw in coupling base firing device F4.<br>(4) Place an object so that at least 2 lb force presses down on Point F.<br>(5) Remove pin with round head using a wire if necessary.<br>(6) Withdraw safety pin, using a wire if necessary. If safety pin resists movement, do not withdraw, recheck setting.<br>**REMEMBER—REMOVE ROUND FOR RELEASE** | |
| | |  | **TENSION RELEASE**<br>(1) Check safety pin for ease of removal and reinsert.<br>(2) Secure switch to a fixed object with nails, screws, or wire.<br>(3) Screw in coupling base firing device F4.<br>(4) Fit tension release device and loop end of wire over curved neck N.<br>Adjust tension in tripwire until N lines up with set point S.<br>Make sure pull is in the direction shown on the diagram.<br>(5) Remove pin with round head.<br>(6) Withdraw safety pin.<br>If safety pin resists movement, do not withdraw, recheck setting.<br>**REMEMBER—REMOVE ROUND FOR RELEASE** | |

## Scatterable Mine Characteristics

Table 3-19. Scatterable mine characteristics

| ANTIPERSONNEL | SYSTEM | CASUALTY RADIUS | TYPE MINE | ACTUATION | SELF DESTRUCT OPTIONS |
|---|---|---|---|---|---|
|  | GEMSS | 10 15M | Blast | Tripwire (20 40) | 2 |
| | GATOR | | | | 3 |
| | MOPMS | | | | Adjustable |
| | VOLCANO | | | | 3 |
| | FLIPPER | | | | 2 |
|  | ADAMS | 6 10M | Bounding | Tripwire | 2 |

| ANTITANK | SYSTEM | TYPE KILL | ACTUATION | SELF DESTRUCT OPTIONS |
|---|---|---|---|---|
|  | GEMSS/FLIPPER | K | Magnetic Influence | 2 |
| | GATOR | | | 3 |
| | MOPMS | | | Adjustable |
| | VOLCANO | | | 3 |
| | RAAMS | | | 2 |
|  | M56 | M | Pressure | 1 |

| ANTITANK | SYSTEM | TYPE KILL | ACTUATION | SELF DESTRUCT OPTIONS |
|---|---|---|---|---|
|   | WASPM | K | Acoustical | Adjustable |

NOTE: M Mobility Kill
K = Crew Kill

CAUTION

1. Antipersonnel tripwire may not deploy properly if mines land in mud or snow.
2. Mine antihandling devices may cause premature destruction of mines if placed on snow.
3. Mine self destruct times are classified CONFIDENTIAL and are available through unit.

## EXPEDIENT MINES

Improvised mine construction must consider safety, neutralization, and disarming requirements. Authorization of employment depends on the minefield in which the mine is to be used (Table 3-7, page 3-17). Figures 3-42 through 3-49 (pages 3-49 through 3-54) provide design and function guidance for expedient mines. The actual construction may depend on material availability.

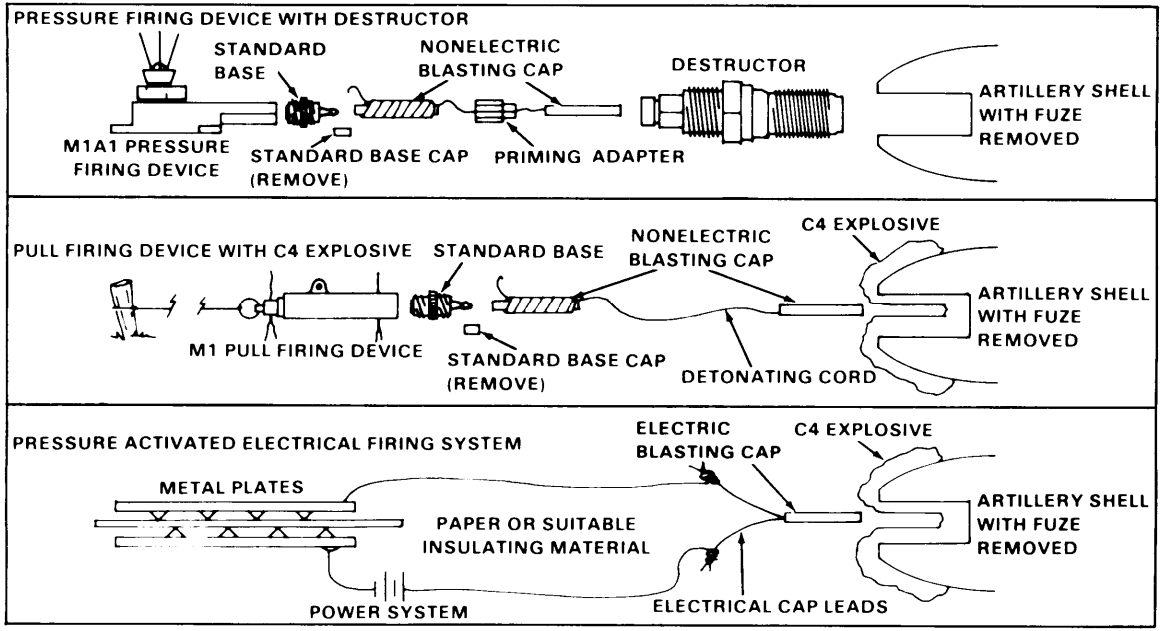



Figure 3-42 High explosive artillery shell AT mine with three different firing systems

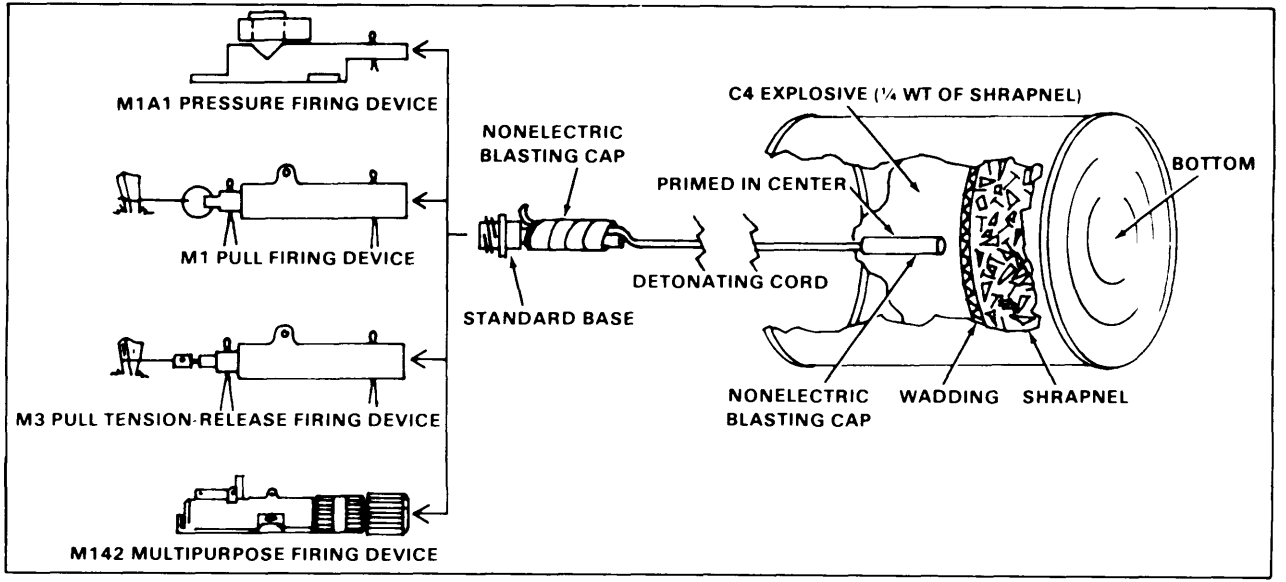



Figure 3-43. Grapeshot AP mine

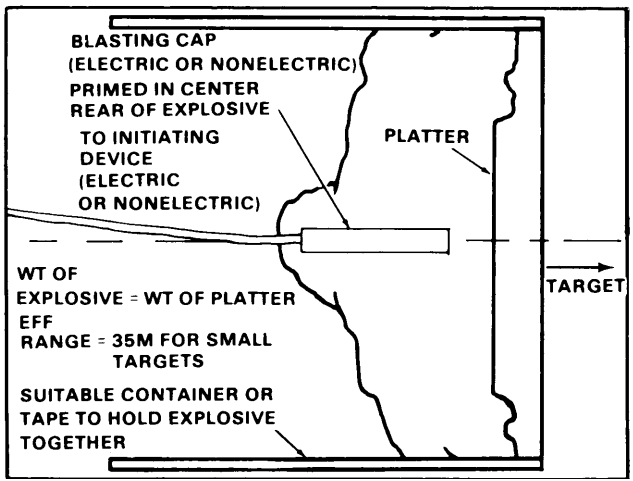



Figure 3-44. Plate charge expedient mine

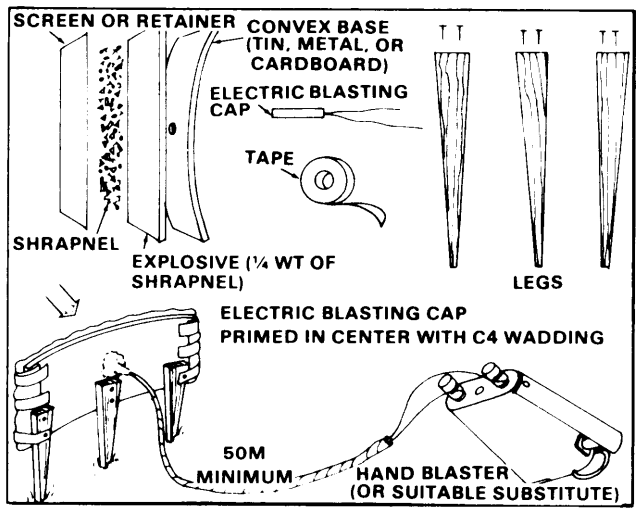



Figure 3-45. Improvised claymore mine

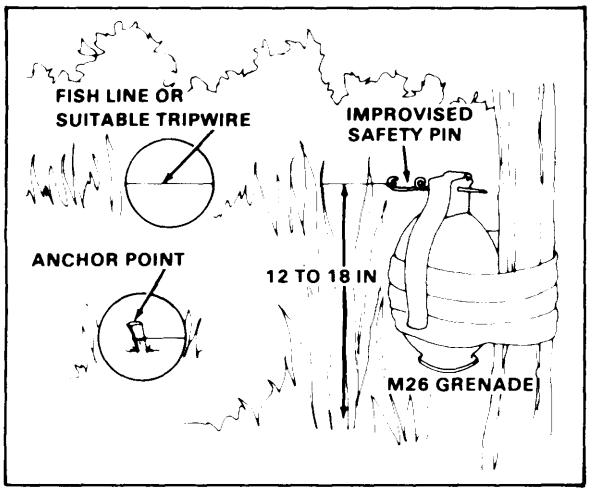



Figure 3-46. Fragmentation grenade mine (5 second delay)

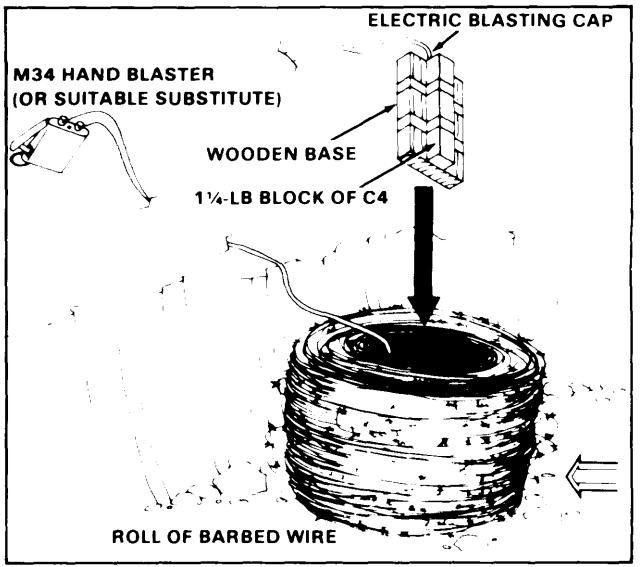



Figure 3-47. Barbed wire expedient mine

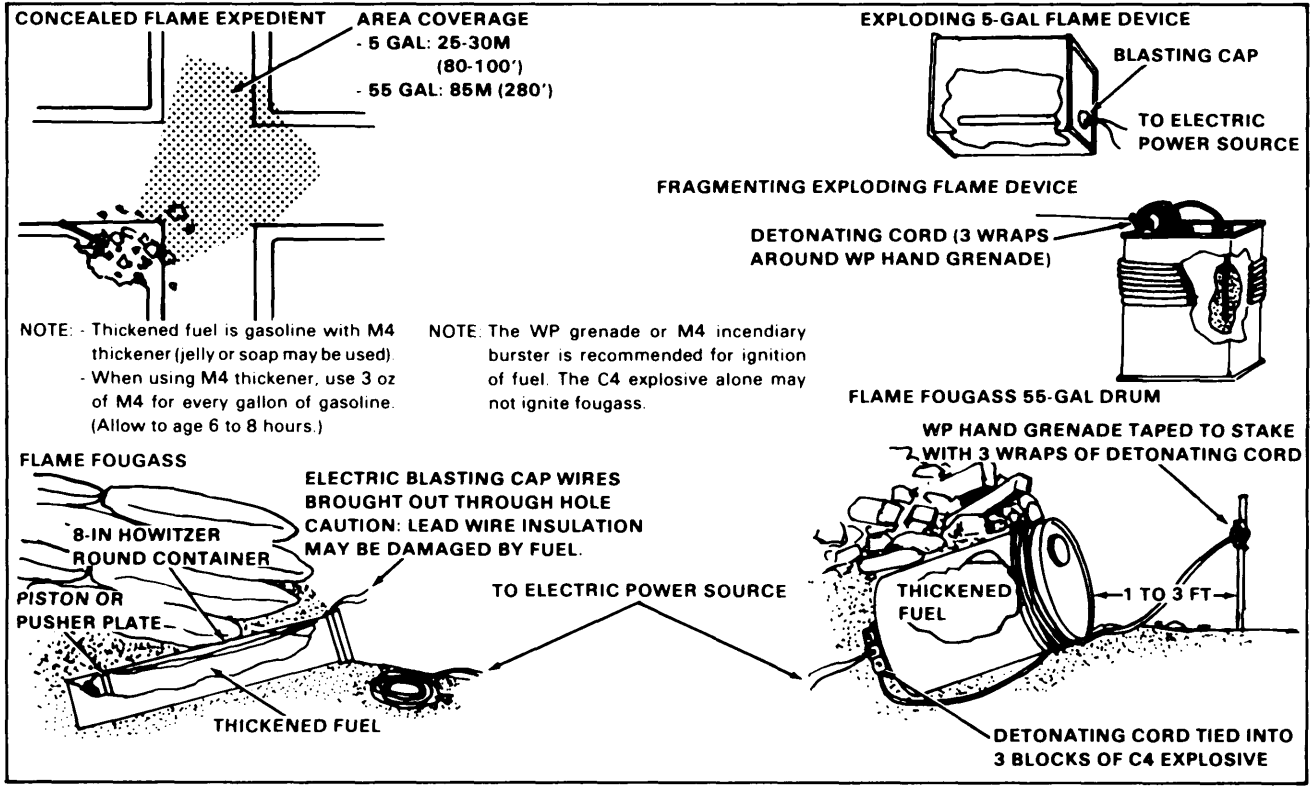



Figure 3-48. Improvised flame mines

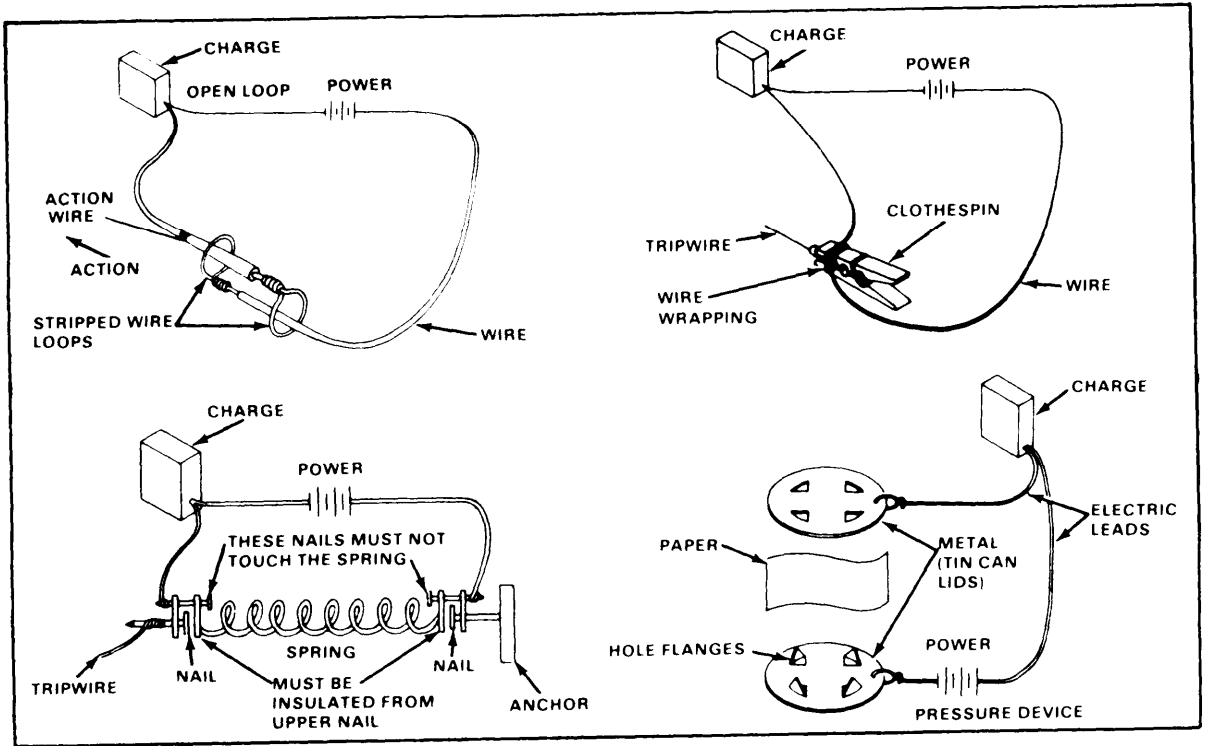



Figure 3-49. Expedient firing devices

# CHAPTER 4

## Survivability

### WEAPONS FIGHTING POSITIONS

Positions may be hasty or deliberate depending on time and material availability Positions may be dug by hand or mechanically (with JD410). Table 4-1 shows required thickness for protection against direct and indirect fire.

Table 4-1. Material thickness (cm/in) required to protect against direct and indirect fire

| MATERIAL | DIRECT FIRE | | | INDIRECT FIRE (Blast exploding 50 feet away) | | |
|---|---|---|---|---|---|---|
| | SMALL CALIBER (7.62 MM) | HE SHAPED CHARGE | | MORTAR | MORTAR/ ROCKET/HE SHELL | |
| | | 85 MM (RPG7) | 107-120 MM (RCLR) (SAGGER) | 82 MM | 120 MM 122 MM | 152 MM |
| Concrete | 30 (12) | 76 (30) | 91 (36) | 10 (4) | 13 (5) | 15 (6) |
| Gravel, small rocks, bricks, rubble | 51 (20 | 61 (24) | 91 (36) | 25 (10) | 46 (18) | 51 (20) |
| Soil, sand | 107 (42) | 198 (78) | 244 (96) | 30 (12) | 51 (20) | 76 (30) |
| Timber | 91 (36) | 229 (90) | 274 (108) | 20 (8) | 30 (12) | 36 (14) |
| Snow (tamped) | 183 (72) | 396 (156) | None | 152 (60) | 152 (60) | 152 (60) |

### Individual Fighting

Table 4-2 and Figures 4-1 through 4-3 (pages 4-2 and 4-3) show details and characteristics of different individual positions. The light antitank weapon (LAW) may be fired from any of these positions however backblast area must be cleared prior to firing.

Table 4-2 Characteristics of Individual fighting positions

| TYPE OF POSITION | ESTIMATED CONSTRUCTION TIME W/HAND TOOLS (MAN-HOURS) | NUCLEAR WEAPONS |
|---|---|---|
| HASTY | | |
| Crater | 0.2 | Fair |
| Skirmisher's trench | 0.5 | Fair |
| Prone position | 1.0 | Fair |
| DELIBERATE | | |
| One-soldier position | 3.0 | Fair |
| One-soldier position with 1½-ft overhead cover | 8.0 | Good |
| Two-soldier position | 6.0 | Fair |
| Two-soldier position with 1½-ft overhead cover | 11.0 | Good |
| LAW position | 3.0 | Fair |

NOTES:
1. All deliberate postions provide protection from medium artillery no closer than 30 feet.
2. All positions provide no protection from indirect fire blasts or direct hits from indirect fire.

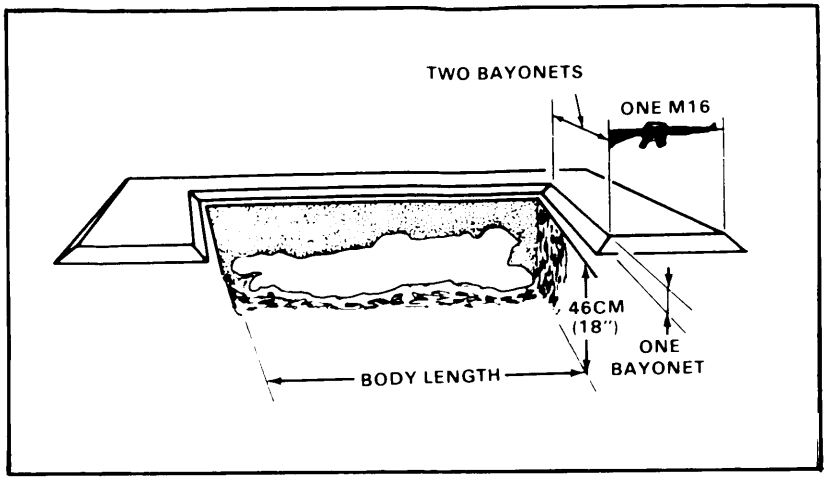



Figure 4-1 Hasty prone position (stage 1)



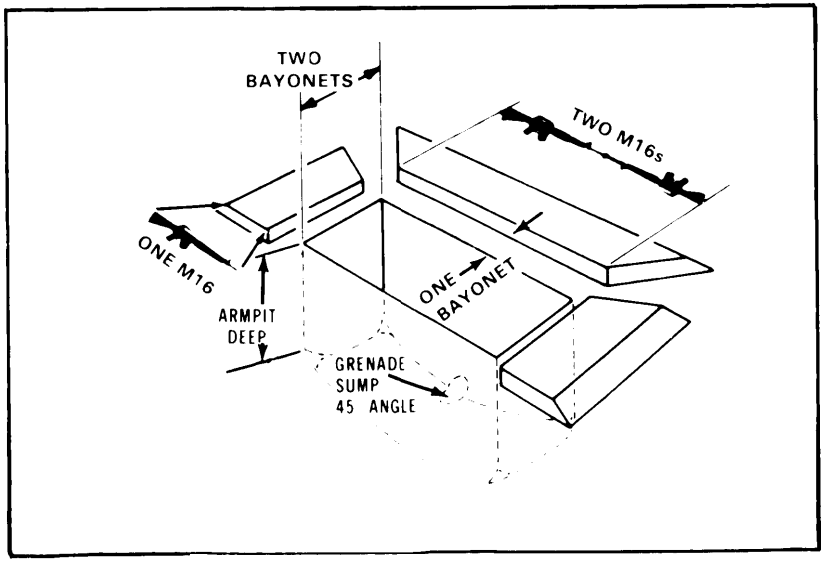



Figure 4-2 Two-soldier firing position (stage 2)

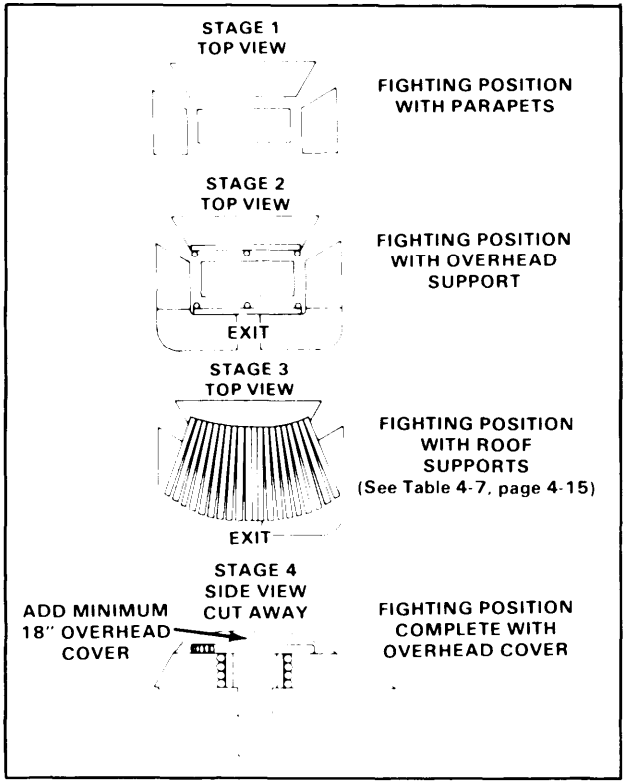



Figure 4-3. Two-soldier fighting position development

## Crew-Served Weapons Fighting

See Table 4-3 and Figures 4-4 through 4-9 (paqes 4-4 through 4-7) for specifications and details.

Table 4-3. Characteristics of crew-served weapons positions

| TYPE OF POSITION | ESTIMATED CONSTRUCTION TIME W/HAND-TOOLS (MAN-HOURS) | NUCLEAR WEAPONS |
|---|---|---|
| Dragon position | 4.0 | Fair |
| Dismounted TOW position | 11.0 | Fair |
| 90mm RCLR position | 6.0 | Fair |
| Machine gun position | 7.0 | Fair |
| Machine gun position with 1½-ft overhead cover | 12.0 | Good |
| Mortar position | 14.0 | Fair |

NOTES:

1. All positions provide protection from medium artillery no closer than 30 feet.
2. All positions provide no protection from indirect fire blasts or direct hits from indirect fire.

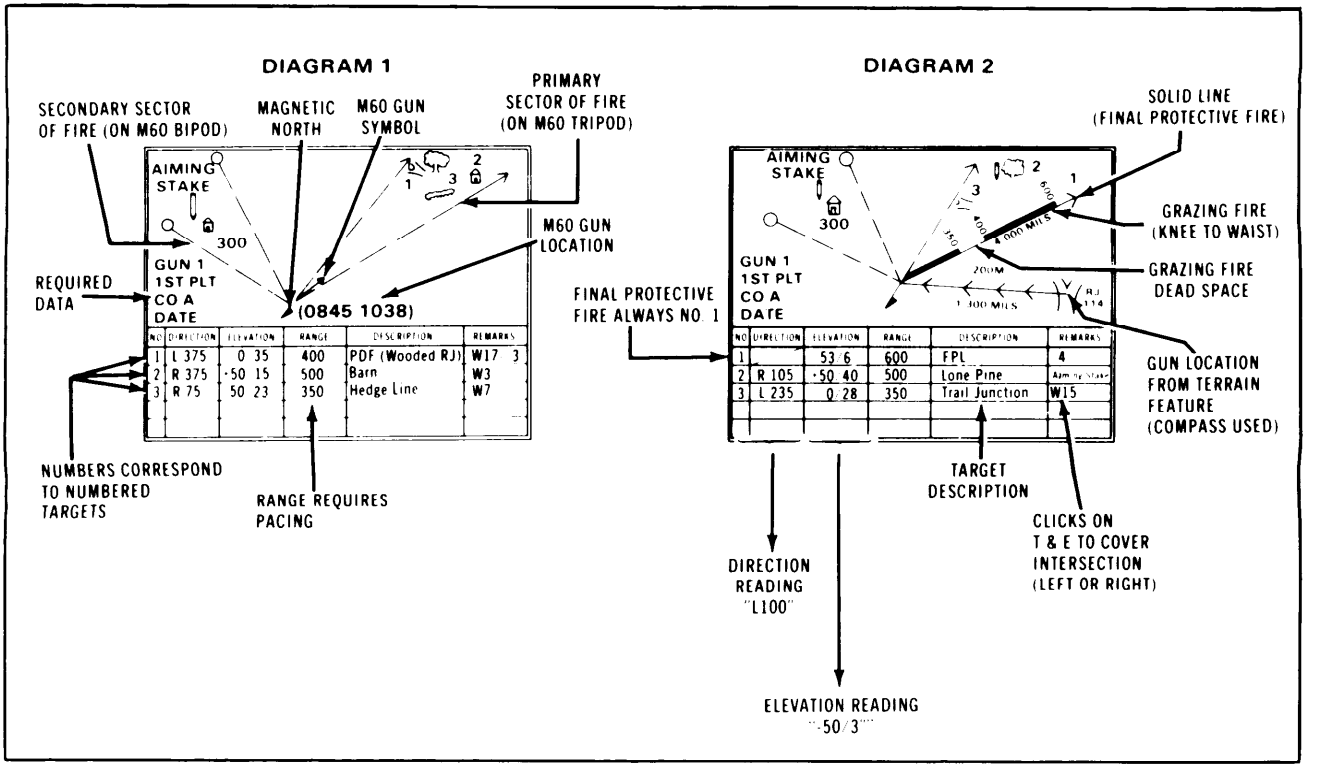



Figure 4-4. Range card

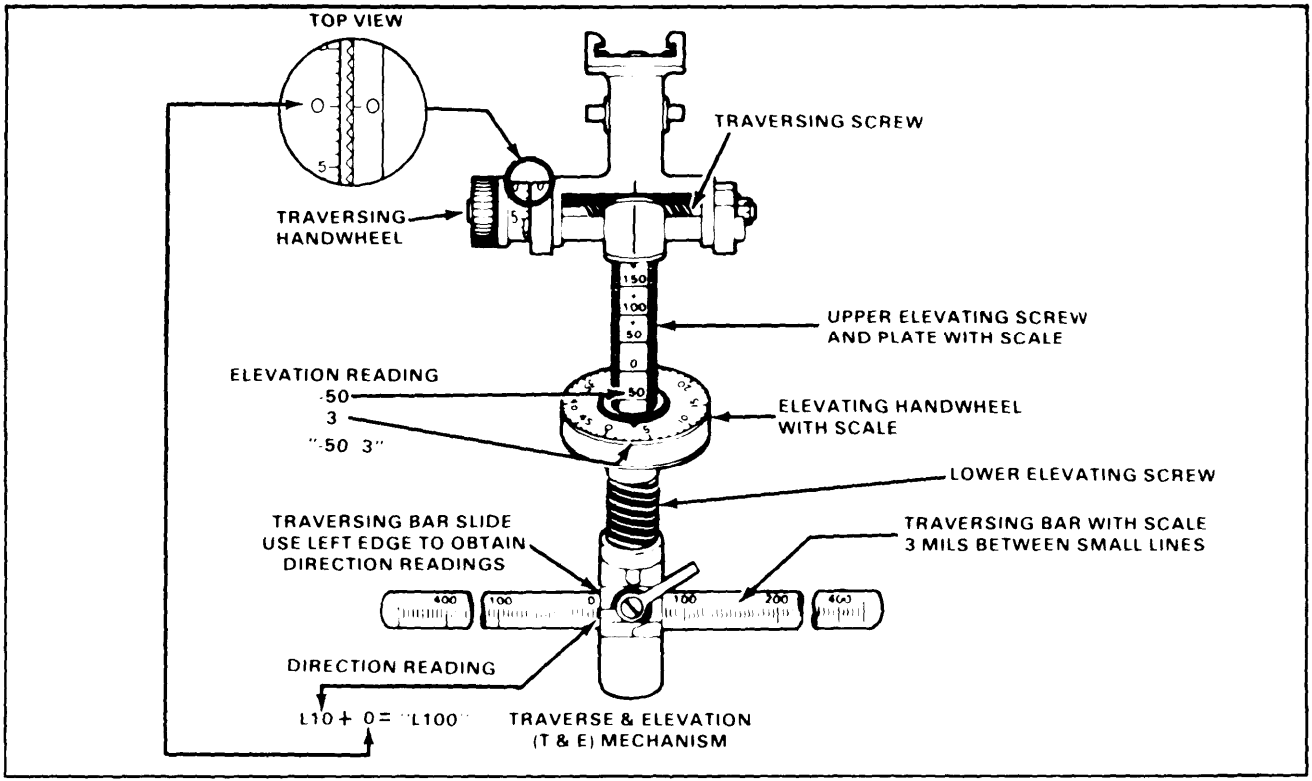
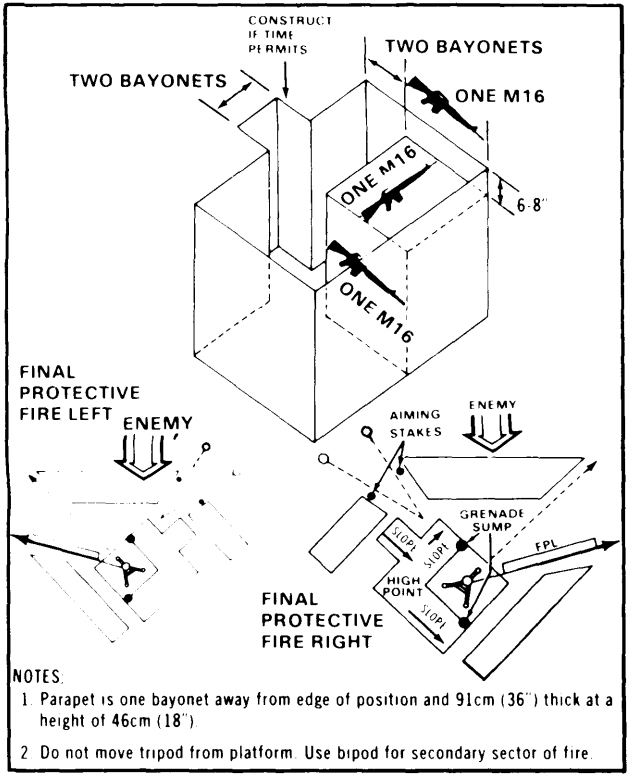



Figure 4-4. Range card (continued)




NOTES:

1. Parapet is one bayonet away from edge of position and 91cm (36") thick at a height of 46cm (18").
2. Do not move tripod from platform. Use bipod for secondary sector of fire.

Figure 4-5. Machine gun position

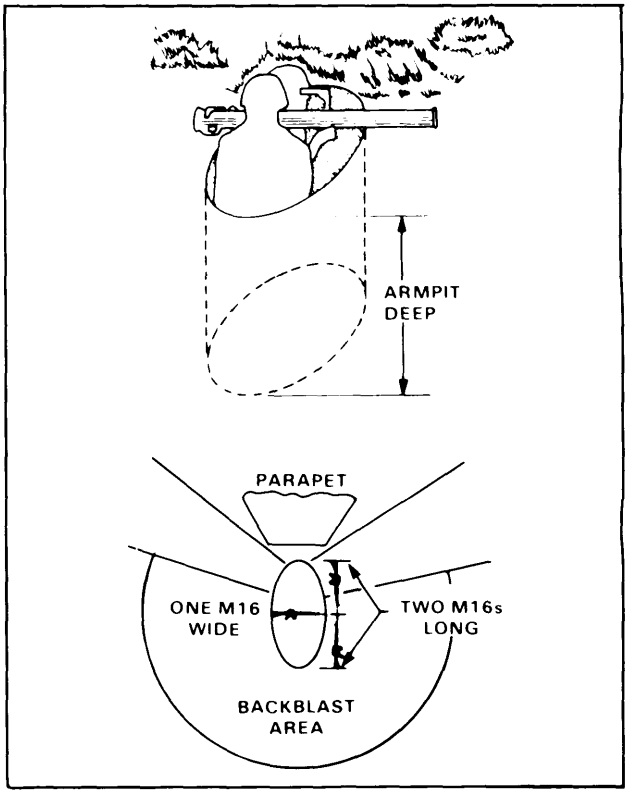



Figure 4-6. 90mm firing position

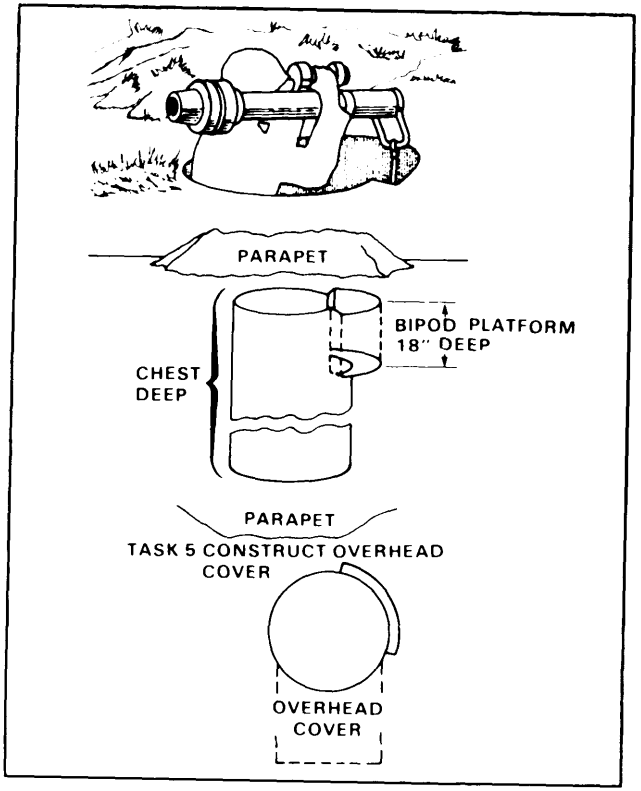



Figure 4-7. Dragon position

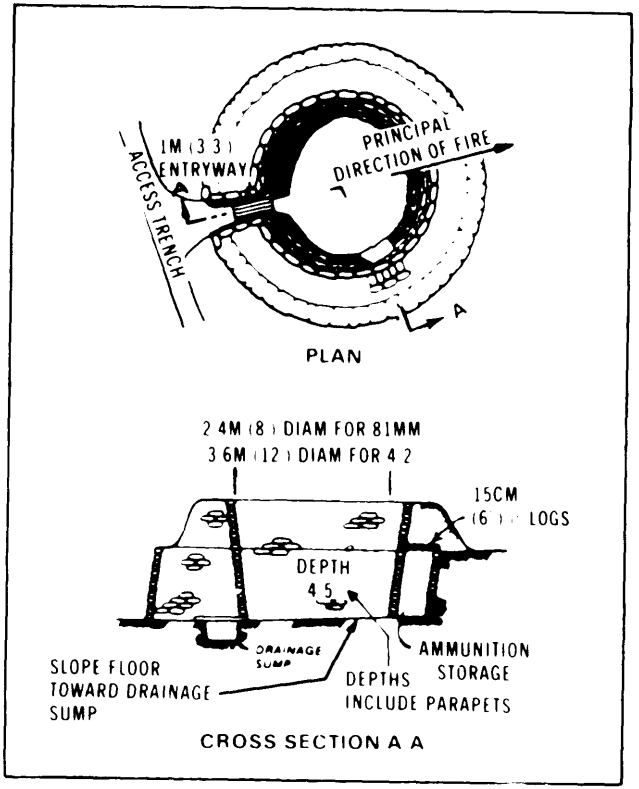



Figure 4-8. Mortar (4.2 in and 81 mm) improved position

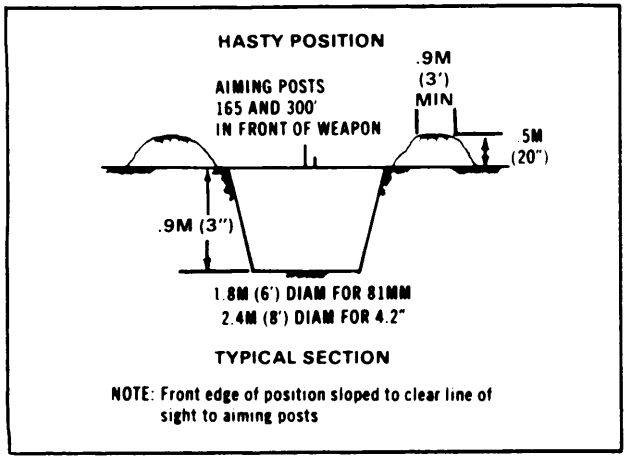



Figure 4-9. Mortar hasty position

## VEHICLE POSITIONS

Positions may be fighting or protective, hasty or deliberate. See Table 4-4 for estimated survivablility positions for maneuver units.

### WARNING

**ENSURE ENGINEER EQUIPMENT (SCOOP LOADERS, M9 (ACE)s. SCRAPERs) BOWLS ARE PERIODICALLY EMPTIED AND NEVER ALLOWED TO REMAIN FILLED OVERNIGHT, PARTICULARLY DURING COLD WEATHER.**

Table 4-4. Standard survivability estimates for maneuver units

| LEVEL | DESCRIPTION OF RECOMMENDED PRIORITY OF SURVIVABILITY SUPPORT | | NUMBER OF HULL-DOWN POSITIONS TO BE PROVIDED PER BATTLE POSITION | | | |
|---|---|---|---|---|---|---|
| | | | ARMOR BN | MECH INF BN | ARMOR CO | MECH INF CO |
| 1 | TOWs | P | | | | |
| | Tanks | P | | | | |
| | APC (Plt and Co HQ only) | 50% P | | | | |
| | TOC | P | 80 | 100 | 15 | 15 |
| 2 | TOWs | P and A | | | | |
| | Tanks | P | | | | |
| | APC (Plt and Co HQ only) | P | | | | |
| | TOC | P | 85 | 175 | 15 | 25 |
| 3 | TOWs | P and A | | | | |
| | Tanks | P and A | | | | |
| | APC (Plt and Co HQ only) | P | | | | |
| | TOC | P | | | | |
| | Combat Support | P | 150 | 180 | 30 | 25 |
| 4 | TOWs | P and A | | | | |
| | Tanks | P and A | | | | |
| | APC (all) | P | | | | |
| | TOC | P | | | | |
| | Combat Support | P | | | | |
| | Combat Train | 50% P | 160 | 190 | 30 | 30 |
| 5 | TOWs | P. A. and S | | | | |
| | Tanks. APC (all) | P and A | | | | |
| | TOC | P | | | | |
| | Combat Support | P | | | | |
| | Combat Train | P | 185 | 295 | 45 | 40 |
| 6 | TOWs. Tanks and APC (all) | P. A. and S | | | | |
| | TOC | P and A | | | | |
| | Combat Support | P and A | | | | |
| | Combat Train | P | 265 | 330 | 45 | 45 |

NOTES:

1. P=Primary, A=Alternate, S=Supplementary hull-down positions.
2. Numbers are rounded to the nearest 5.
3. Combat support vehicles comprise mortars and ADA.
4. Platoon and Co HQ only Allows for four APCS per platoon and two per Co HQ to be dug in.

## Hasty Fighting

See Figure 4-10. Berms will not protect vehicles from enemy armor fire.

| | Length (l) | Width (w) | Height (h) | Time (hr/min) |
|---|---|---|---|---|
| M113 Series Carrier | 7 | 4.5 | 2 | 0/36 |
| M577 Command Post Vehicle | 7 | 4.5 | 3 | 0/48 |
| M106 and M125 Mortar Carrier | 7 | 5 | 2.5 | 0/42 |

NOTE: Hasty positions for tanks, IFVs and ITVs not recommended.
All dimensions are in meters.

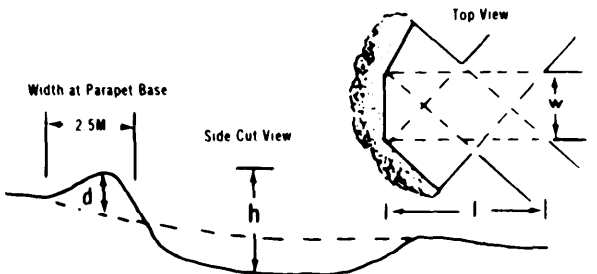
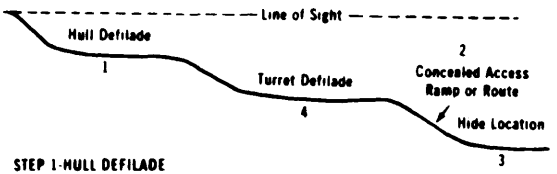



Figure 4-10. Hasty fighting positions for combat vehicles

## Deliberate Fighting

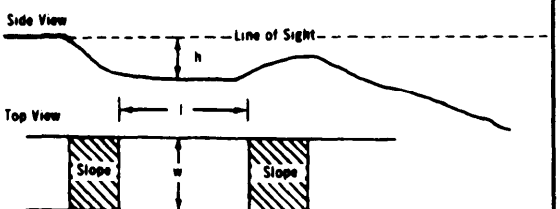
SEQUENCE OF CONSTRUCTION

STEP 1 - Hull Defilade
STEP 2 - Concealed Access Ramp or Route
STEP 3 - Hide Location
STEP 4 - Turret Defilade




STEP 1-HULL DEFILADE

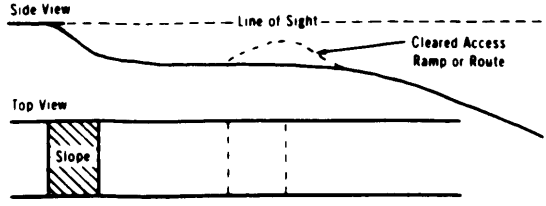
| | Length (l) | Width (w) | Height (h) | Time (hr/min) |
|---|---|---|---|---|
| M1 Main Battle Tank | 10 | 5.5 | 2 | 0/54 |
| M60/M48 Series Battle Tank | 9.5 | 5.5 | 2 | 0/54 |
| M2 and M3 Fighting Vehicle | 8 | 5 | 2.5 | 0/48 |
| M901 Improved TOW Vehicle | 7 | 4.5 | 2 | 0/36 |




NOTE: Slope equals 3:1 (Approximately 33°)
All dimensions are in meters.

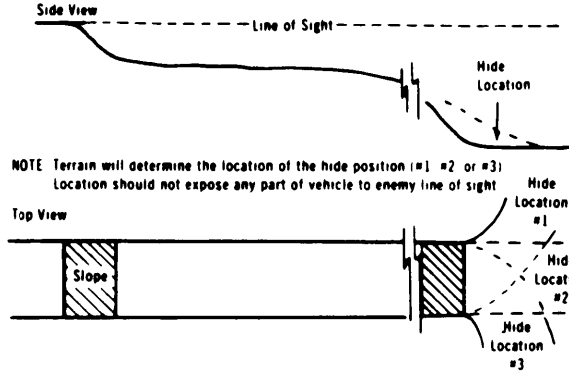
Figure 4-11. Deliberate fighting positions for fighting vehicles

STEP 2 CONCEALED ACCESS RAMP OR ROUTE




NOTE Slope equals 3 1 (Approximately 33°)
All dimensions are in meters

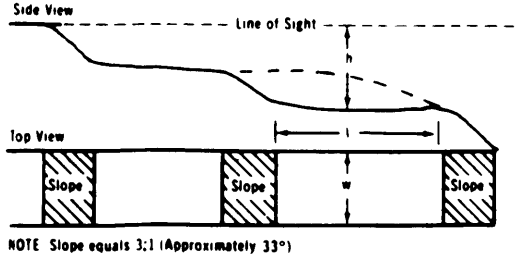
STEP 3 HIDE LOCATION




NOTE Terrain will determine the location of the hide position (#1 #2 or #3)
Location should not expose any part of vehicle to enemy line of sight

STEP 4 TURRET DEFILADE

| | Length (l) | Width (w) | Height (h) | Time (hr min) |
|---|---|---|---|---|
| M1 Main Battle Tank | 10 | 5 5 | 3 | 1 30 |
| M60 M48 Series Battle Tank | 9 5 | 5 5 | 3 | 1 30 |
| M2 and M3 Fighting Vehicle | 8 | 5 | 3 | 1 12 |
| M113 Series Carrier | 7 | 4 5 | 2 5 | 0 42 |
| M901 Improved Tow Vehicle | 7 | 4 5 | 3 | 0 48 |




NOTE Slope equals 3:1 (Approximately 33°)
All dimensions are in meters

Figure 4-11. Deliberate fighting positions for fighting vehicles (continued)

## Protective

### Artillery and parapet

See Table 4-5 and Figure 4-12 for details. For field artillery platform, refer to Field Manual (FM) 5-103 for details

Table 4-5. Dimensions of field artillery vehicle positions

| VEHICLE TYPE | DIMENSION[1] | | | EQUIPMENT HOURS[3] (D7 DOZER/ M9 ACE) | MINIMUM PARAPET THICKNESS AT BASE M (FT) | REMARKS |
|---|---|---|---|---|---|---|
| | LENGTH M (FT) | WIDTH M (FT) | DEPTH[2,4] M (FT) | | | |
| Chaparral (M730) and self-propelled Hawk | 7.8 (26) | 4.5 (15) | 1.2 (4) | 0.5 | 2.4 (8) | |
| General support rocket launcher | 8 (27) | 5.1 (17) | 9 (3) | 0.4 | 2.4 (8) | |
| 155-mm self-propelled howitzer (M109) | 32 (107) | 5.4 (18) | 1.5 (5) | 2.7 | 2.4 (8) | * |
| 175-mm self-propelled gun (M107) | 31.5 (105) | 4.8 (16) | 1.5 (5) | 2.4 | 2.4 (8) | * |
| 8-in self-propelled howitzer (M110) | 32.4 (108) | 5 (17) | 1.5 (5) | 2.6 | 2.4 (8) | * |

*Length accomodates ammunition supply vehicles

NOTES: 1. Position dimensions provide an approximate 9m (3 ft) clearance around vehicle for movement and maintenance and do not include ramp(s).

2. Total depth includes any parapet height.

3. Production rate of 100 bank cubic yards per 0.75 hour. Divide construction time by 0.85 for rocky or hard soil, night conditions, or closed hatch operations (M9). Use of natural terrain features will reduce construction time.

4. All depths are approximate and will need adjustment for surrounding terrain and fields of fire.

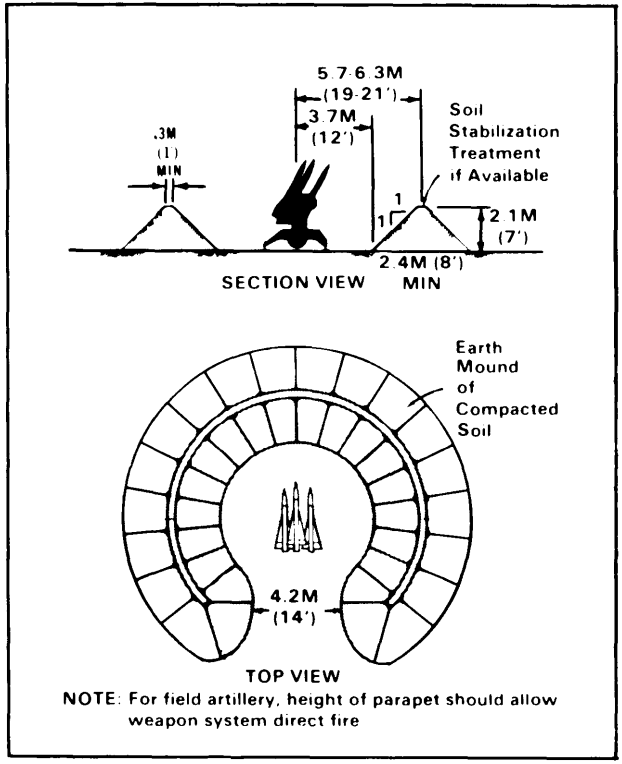



Figure 4-12. Parapet position construction detail

## Deep-cut

See Table 4-6 and Figure 4-13

Table 4-6. Dimensions of typical deep-cut position

| VEHICLE TYPE | DIMENSION[1] | | | EQUIPMENT HOURS[3] (D7 DOZER/ M9 ACE) | REMARKS |
|---|---|---|---|---|---|
| | LENGTH M (FT) | WIDTH M (FT) | DEPTH[2,4] M (FT) | | |
| ¼-ton truck/CUCV | 5.4 (18) | 3.6 (12) | 2.1 (7) | 0.5 | Add 2.7m (9 ft) to length for cargo trailer |
| 1¼-ton truck/ HUMMV | 6 (20) | 3.9 (13) | 2.7 (9) | 0.7 | Add 1.5m (5 ft) to length for gamma goat (M561) |
| 2½-ton cargo truck | 8.7 (29) | 3.9 (13) | 3 (10) | 1.1 | Add 4.2m (14 ft) to length for cargo or water trailer |
| 2½-ton shop van | 8.4 (28) | 4.2 (14) | 3.6 (12) | 1.3 | |
| 5-ton cargo truck | 11.4 (38) | 4.2 (14) | 3 (10) | 1.5 | |
| 5-ton shop van | 10.8 (36) | 4.2 (14) | 3.6 (12) | 1.7 | |
| 10-ton cargo truck | 10.2 (34) | 4.8 (16) | 3.6 (12) | 1.9 | |
| 10-ton tractor w/ van semitrailer | 15.9 (53) | 4.8 (16) | 3.6 (12) | 2.9 | Dimensions shown are for trailer length of 9.3m (30.8 ft). For other trailers, add 6.9m (23 ft) to actual trailer length |

NOTES: 1. Position dimensions provide an approximate 9m (3 ft) of clearance around vehicle for movement and maintenance and do not include ramp(s).

2. Production rate of 100 bank cubic yards per 0.75 hour. Divide construction time by 0.85 for rocky or hard soil night conditions or closed hatch operations (M9). Use of natural terrain features will reduce construction time.

3. Ensure drainage is provided.

4. See Table 8-4 (page 8-9) for minimum slope cut ratios.

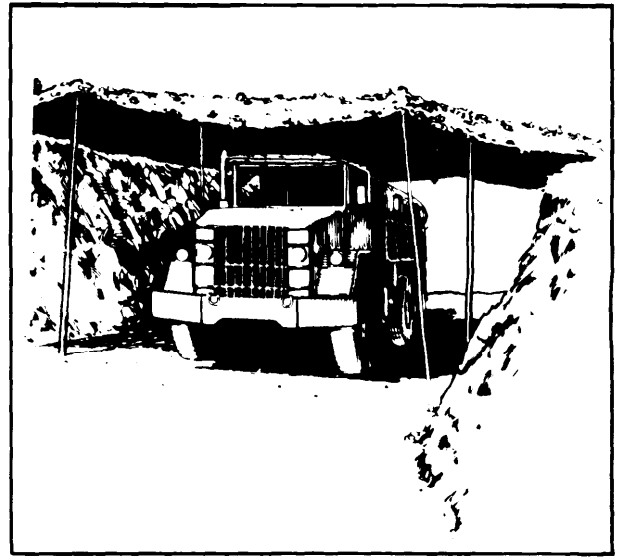


Figure 4-13. Deep cut position

## Trenches

Construct trenches to connect fighting positions and provide protection and concealment for personnel moving between position. They may be open with overhead cover or a combination See Figure 4-14.

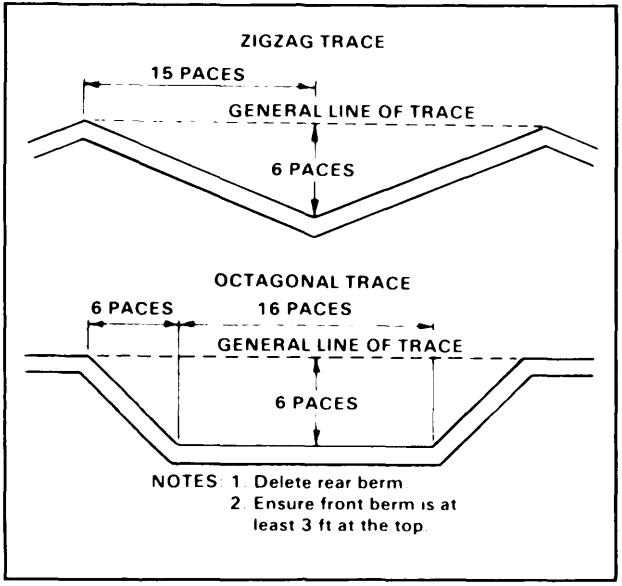



Figure 4-14. Standard trench traces

## Revetments

### Retaining wall

Materials that can be used for a retaining wall are sandbags, sod blocks (20 centimeters x 45 centimeters), lumber, timber and corrugated metal. When using sandbags, fill bags ¾ full with one part cement to 10 parts earth. Place bottom row as header at about 15 centimeters below floor level. Alternate rows as header and stretcher (Figure 4-15). Slope wall toward revetted face at 1 to 4 slope ratio. See Figure 4-16 (page 4-14) for anchoring method.

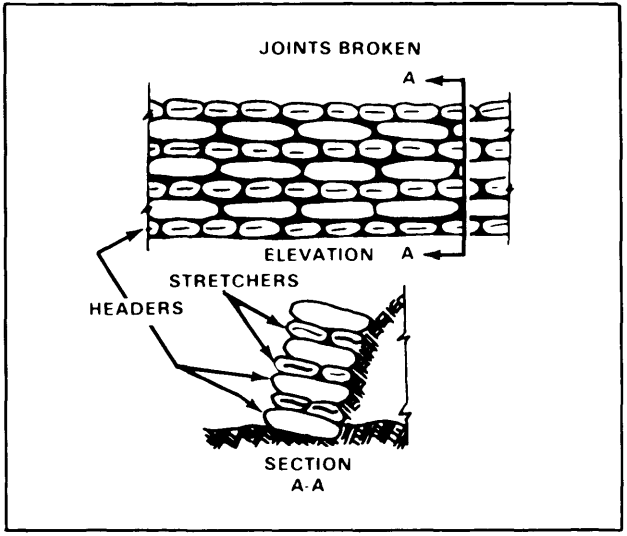



Figure 4-15. Sandbag revetment

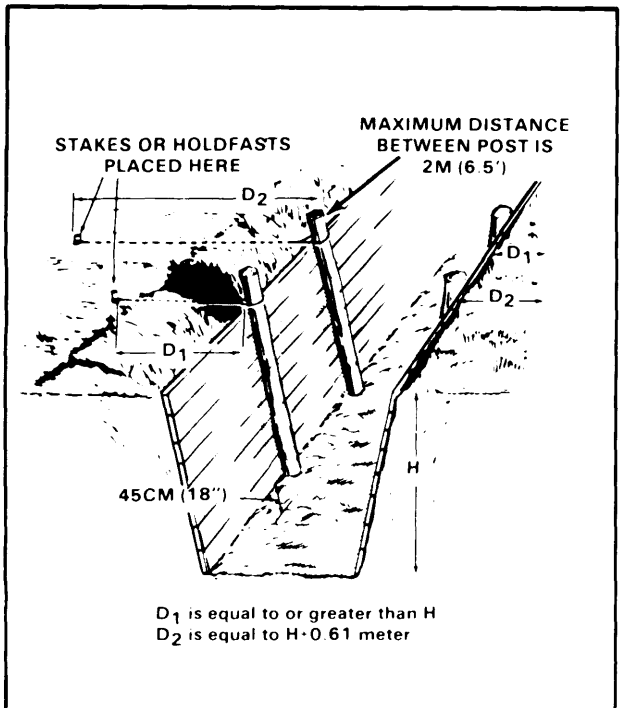



Figure 4-16. Lumber retaining wall anchoring method

## Facing revetments

Mainly used to protect surfaces from weather and damage by occupation. Construction material may be brushwood hurdles (Figure 4-17) continuous brush pole and dimensional timbers, corrugated metal or burlap and chicken wire. To emplace a facing revetment tickets should be 8 centimeters (3 inches) in diameter or larger and at a maximum spacing of 1.75 meters (5.7 feet). Pickets should be driven into the ground af least 5 meter(1.6 feet) and anchored at the top IAW Figure 4-16.

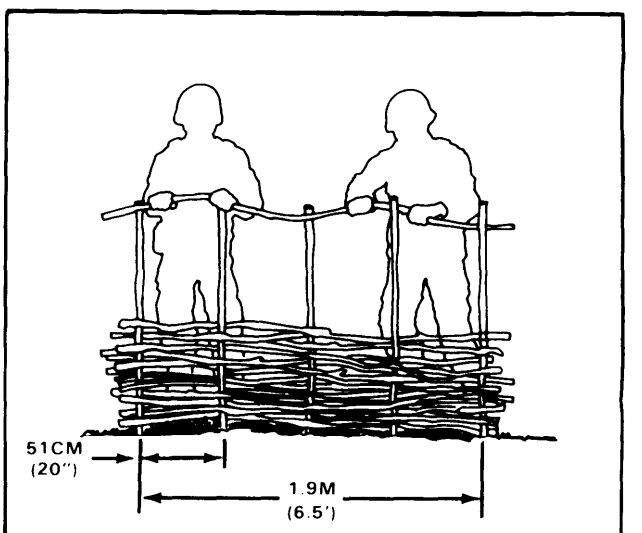



Figure 4-17. Brushwood hurdle

## Bunkers

Basic criteria to consider when designing a bunker are the purpose (command post or fighting position) and the degree of protection desired (small arms, mortars, bombs) (Table 4-1, page 4-1). Table 4-7 shows design figures to defeat contact bursts. The bunker can be constructed wholly or partly underground. Prefabrication of bunker assemblies (wall and roof) afford rapid construction and placement flexibility. When using timber, avoid notching construction timber. Common field bunkers are shown Figures 4-18 and 4-19, (pages 4-16 and 4-17). For other bunker design and construction refer to FM 5-103.

Table 4-7. Center-to-center spacing for wood supporting soil cover to defeat contact bursts

| NOMINAL STRINGER SIZE (INCHES) | DEPTH OF SOIL (d) M (FT) | SPAN LENGTH (L) M (FT) | | | | |
|---|---|---|---|---|---|---|
| | | .6 (2) | 1.2 (4) | 1.8 (6) | 2.4 (8) | 3 (10) |
| | CENTER-TO-CENTER STRINGER SPACING (h) CM (IN) | | | | | |
| | 82-mm Contact Burst | | | | | |
| 2 x 4 | 6 (2) | 7.6 (3) | 10 (4) | 10 (4) | 10 (4) | 8 (3) |
| | 9 (3) | 46 (18) | 30 (12) | 20 (8) | 13 (5) | 8 (3) |
| | 1.2 (4) | 46 (18) | 36 (14) | 18 (7) | 10 (4) | 8 (3) |
| 2 x 6 | 6 (2) | 10 (4) | 18 (7) | 20 (8) | 20 (8) | 15 (6) |
| | 9 (3) | 46 (18) | 46 (18) | 41 (16) | 30 (12) | 20 (8) |
| | 1.2 (4) | 46 (18) | 46 (18) | 46 (18) | 28 (11) | 18 (7) |
| 4 x 4 | .6 (2) | 18 (7) | 25 (10) | 25 (10) | 22 (9) | 18 (7) |
| | .9 (3) | 46 (18) | 46 (18) | 46 (18) | 30 (12) | 20 (8) |
| | 1.2 (4) | 46 (18) | 46 (18) | 46 (18) | 25 (10) | 18 (7) |
| 4 x 8 | 5 (1.5) | 10 (4) | 13 (5) | 18 (7) | 20 (8) | 20 (8) |
| | .6 (2) | 36 (14) | 46 (18) | 46 (18) | 46 (18) | 46 (18) |
| | .9 (3) | 46 (18) | 46 (18) | 46 (18) | 46 (18) | 46 (18) |
| | 120- and 122-mm Contact Bursts | | | | | |
| 4 x 8 | 1.2 (4) | 9 (3.5) | 10 (4) | 13 (5) | 13 (5) | 15 (6) |
| | 1.5 (5) | 30 (12) | 30 (12) | 30 (12) | 28 (11) | 25 (10) |
| | 1.8 (6) | 46 (18) | 46 (18) | 46 (18) | 41 (16) | 30 (12) |
| 6 x 6 | 1.2 (4) | — | — | 14 (5.5) | 15 (6) | 15 (6) |
| | 1.5 (5) | 36 (14) | 36 (14) | 33 (13) | 30 (12) | 25 (10) |
| | 1.8 (6) | 46 (18) | 46 (18) | 46 (18) | 41 (16) | 30 (12) |

| NOMINAL STRINGER SIZE (INCHES) | DEPTH OF SOIL (d) M (FT) | SPAN LENGTH (L) M (FT) | | | | |
|---|---|---|---|---|---|---|
| | | .6 (2) | 1.2 (4) | 1.8 (6) | 2.4 (8) | 3 (10) |
| | CENTER-TO-CENTER STRINGER SPACING (h) CM (IN) | | | | | |
| | 120- and 122-mm Contact Bursts | | | | | |
| 6 x 8 | 1.2 (4) | 14 (5.5) | 15 (6) | 20 (8) | 23 (9) | 25 (10) |
| | 1.5 (5) | 46 (18) | 46 (18) | 46 (18) | 46 (18) | 43 (17) |
| 8 x 8 | 1.2 (4) | 19 (7.5) | 23 (9) | 28 (11) | 30 (12) | 33 (13) |
| | 1.5 (5) | 46 (18) | 46 (18) | 46 (18) | 46 (18) | 46 (18) |
| | 152-mm Contact Burst | | | | | |
| 4 x 8 | 1.2 (4) | — | — | — | — | 9 (3.5) |
| | 1.5 (5) | 15 (6) | 15 (6) | 18 (7) | 18 (7) | 18 (7) |
| | 1.8 (6) | 43 (17) | 41 (16) | 36 (14) | 30 (12) | 25 (10) |
| | 2.1 (7) | 46 (18) | 46 (18) | 46 (18) | 38 (15) | 28 (11) |
| 6 x 6 | 1.5 (5) | 18 (7) | 20 (8) | 20 (8) | 20 (8) | 18 (7) |
| | 1.8 (6) | 46 (18) | 46 (18) | 38 (15) | 30 (12) | 25 (10) |
| | 2.1 (7) | 46 (18) | 46 (18) | 46 (18) | 38 (15) | 28 (11) |
| 6 x 8 | 1.2 (4) | — | — | — | — | 15 (6) |
| | 1.5 (5) | 25 (10) | 28 (11) | 30 (12) | 30 (12) | 30 (12) |
| | 1.8 (6) | 46 (18) | 46 (18) | 46 (18) | 46 (18) | 43 (17) |
| 8 x 8 | 1.2 (4) | — | — | — | — | 20 (8) |
| | 1.5 (5) | 36 (14) | 38 (15) | 41 (16) | 43 (17) | 41 (16) |
| | 1.8 (6) | 46 (18) | 46 (18) | 46 (18) | 46 (18) | 46 (18) |

NOTE: The maximum beam spacing listed in the table is 46cm ( 18 in). This is to preclude further design for roof material placed over the stringers to hold the earth cover.

A maximum of 1-inch wood or plywood should be used over stringers to support the earth cover for 82-mm bursts; 2-inch wood or plywood should be used for 120-mm, 122-mm, and 152-mm bursts.

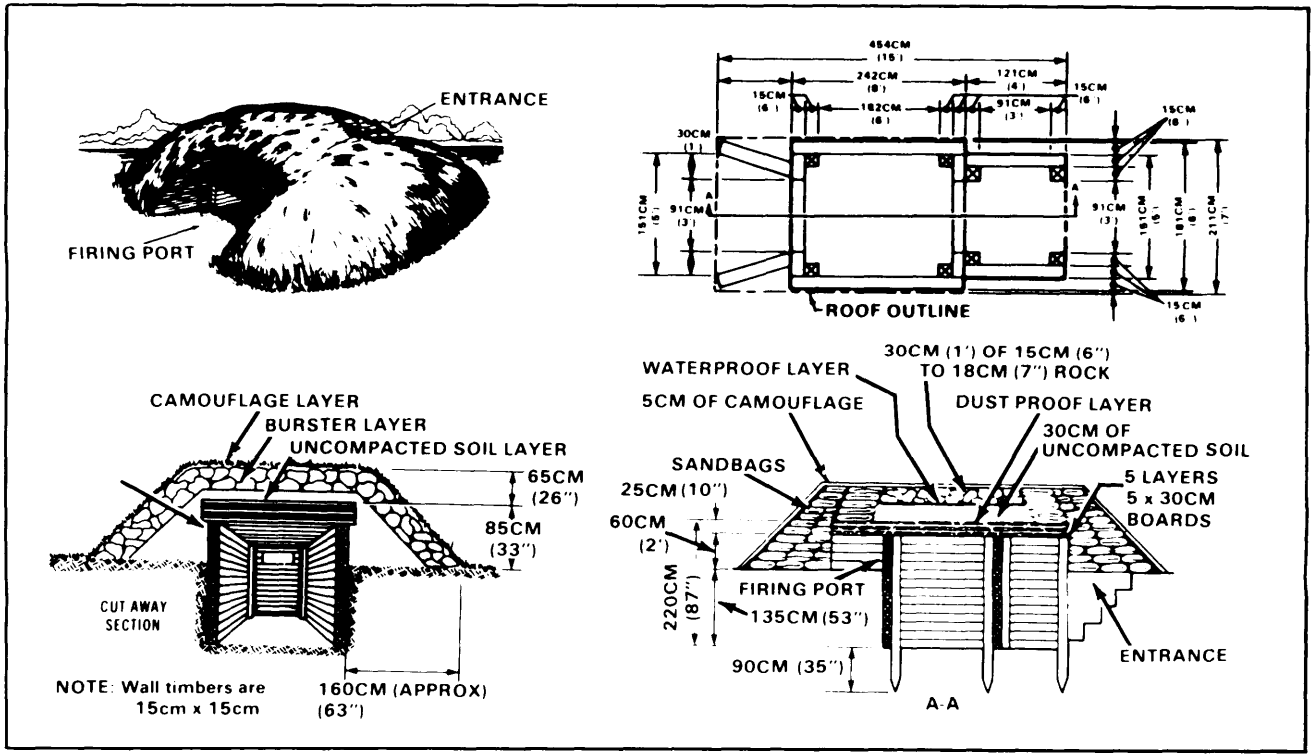



Figure 4-18. Typical bunker

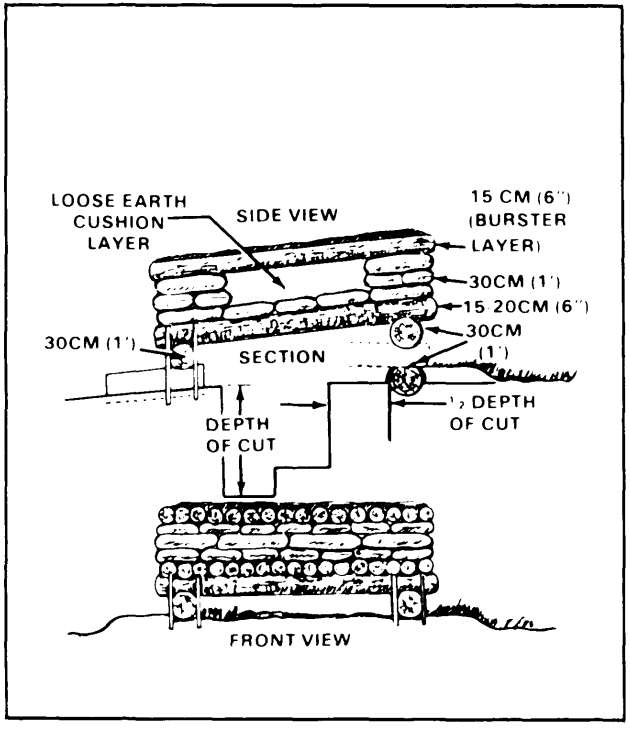



Figure 4-19. Log fighting bunker with overhead cover

**Shelters**

The most effective shelters are cut and cover. Typical shelters are shown in Figures 4-20 and 4-21 (page 4-18). See FM 5-103 for other more permanent and detailed shelters.

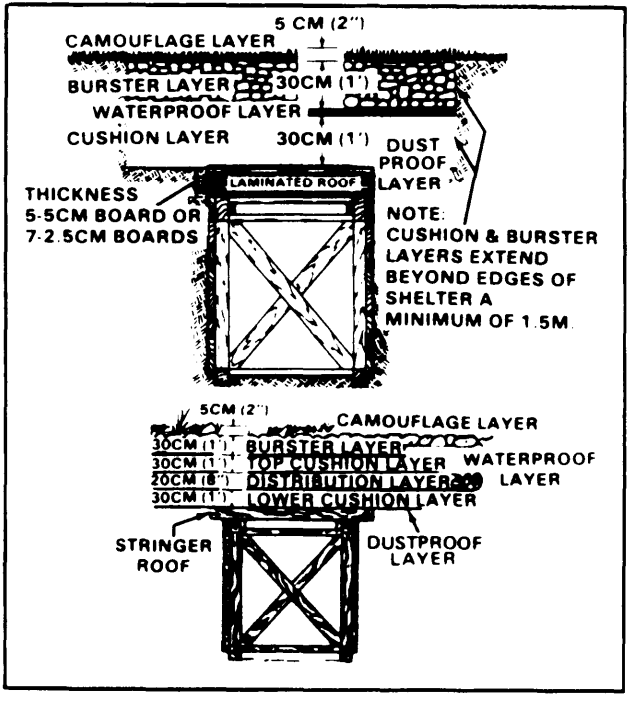



Figure 4-20. Typical cut and cover shelter

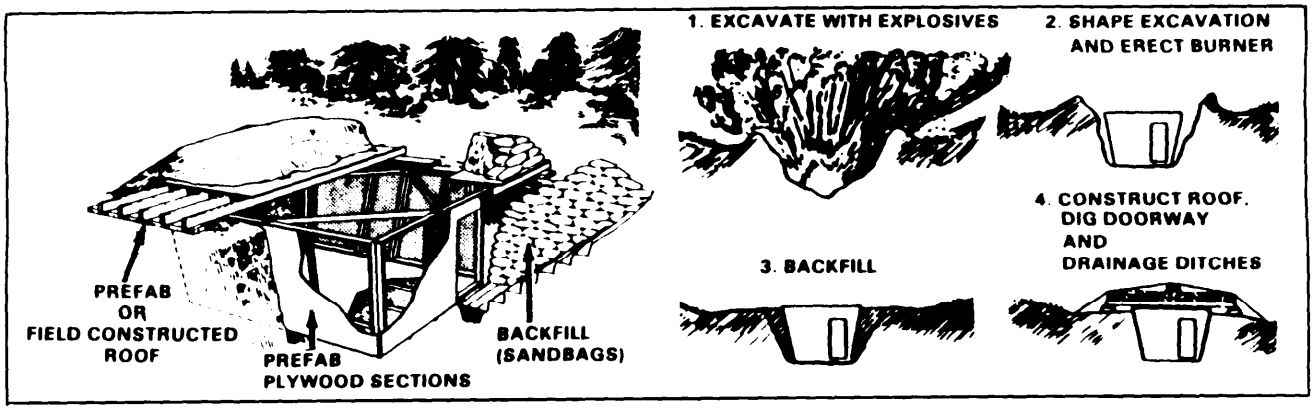



Figure 4-21. Air transportable prefab shelter

## CAMOUFLAGE

The purpose of camouflage is to alter or eliminate recognition(shape, shadow, color texture, position, and movement).

### Materials

Materials for camouflaging may be natural or man made.

#### Natural

Natural materials Include vegetation (growing, cut or dead), inert substances of thet substances of the earth (soil and mud) and debris.

#### Man-made

Man made materials are divided into three groups: hiding and screening (net sets, wire netting, snow fencing, tarpaulins, and smoke); garnishing and texturing (gravel, cinders, sawdust, fabric strips, feather, and spanish moss); and coloring (paints, oil, and grease). Table 4-8 shows expedient paints that can be made in the field.

Table 4-8. Expedient paints

| PAINT MATERIALS | MIXING | COLOR | FINISH |
|---|---|---|---|
| No 1 Local earth, GI soap, water, soot, paraffin | Mix soot with paraffin, add to solution of 8 gal water and ½ lb soap Stir in earth | Dark gray | Flat, lusterless |
| No. 2 Oil, ground clay, water, gasoline, earth | Mix 2 gal water with 1 gal oil and ¼ to ½ gal clay, add earth. Thin with gasoline or water | Depends on earth colors | Glossy on metal; otherwise dull |
| No 3 Oil, clay, GI soap, water, earth | Mix 1½ bars GI soap with 3 gal water, add 1 gal oil; stir in 1 gal clay. Add earth for color | Depends on earth colors | Glossy on metal; otherwise dull |

NOTE: Canned milk or powdered eggs can be used to increase binding properties of either issue of field-expedient paints.

## Position Development Stages

### Planning

Consider the unit's mission, access routes, existing concealment, and size of area.

### Occupation

Carefully control traffic to avoid unnecessary movement and disruption of existing concealment. Mark trails and paths and avoid vehicle spacing less than 30 meters apart. The main congested areas(kitchen, command post, and maintenance must be dispersed.

### Camouflage maintenance

Inspect the area frequently and upgrade as needed. Maintain light and noise discipline to include equipment blackout. Do not create addtional paths or trails.

### Evacuation

Leave area as undisturbed as possible.

## Lightweight Camouflage Screen

### Estimation

Determine required modules to camouflage vehicle and equipment using Figure 4-22.

### Emplacement

Assemble modules into one net (Figure 4-23 page 4-20) and place over vehicle. Keep screen away from all hot surfaces and exhaust systems. Ensure that the appropriate blend (color) is showing. Keep a minimum space of two feet between the net and the vehicle. Screens should never be draped over vehicles (Figure 4-24, page 4-20). Always use the erection set and anchor net system.

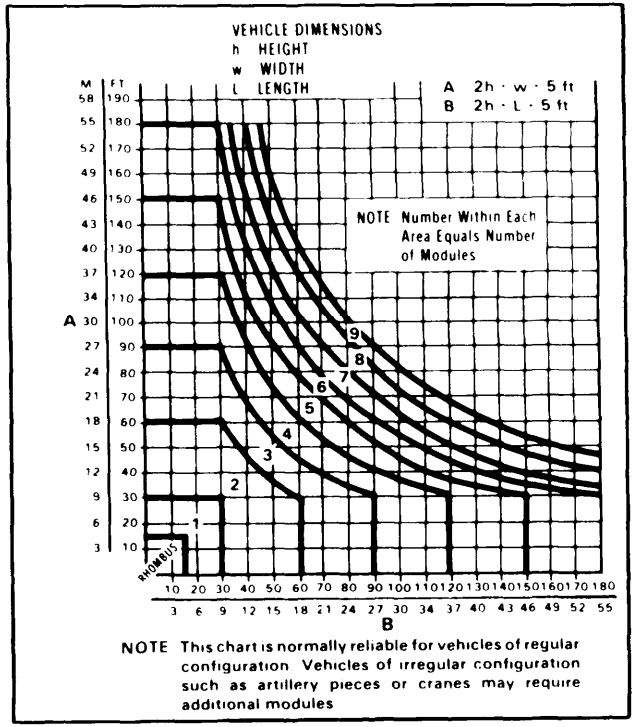



Figure 4-22. Hasty module determination chart

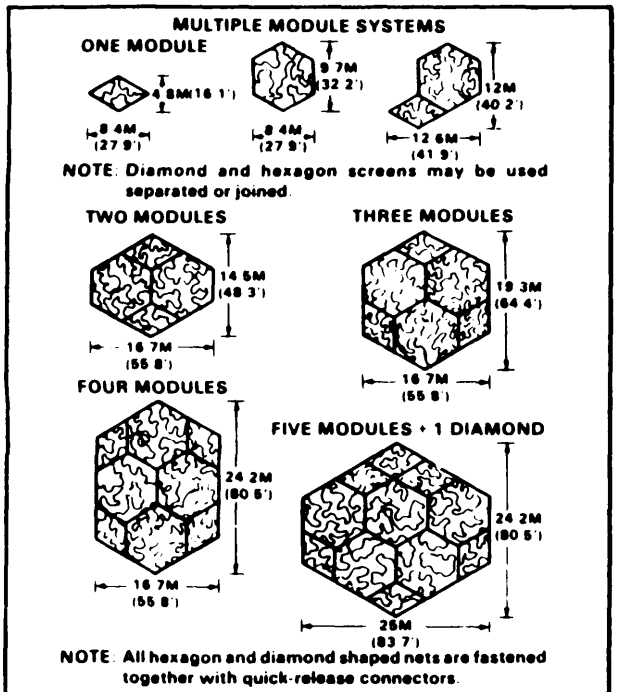



Figure 4-23. Lightweight camouflage screens

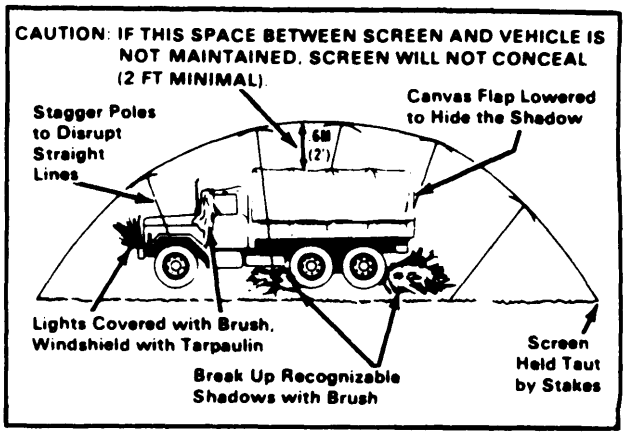



Figure 4-24. Placing net over vehicle

## ROUTE RECONNAISSANCE

Distances will be expressed in **metric** dimensions on at reports

### Critical Features

The following features must be considered:

- Road width slopes, and curves.
- Bridges fords, tunnels ferries, underpasses, swim sites, and other traffic restricting features.
- Obstacles and NBC contaminated areas
- Slide areas
- Drainage
- Other natural and man made features, such as wooded, built up, and possible dispersion areas

### Classification

See Table 5-1 and Figure 5-1

Table 5-1. Route widths

| FLOW POSSIBILITIES | WIDTH FOR WHEELED VEHICLES | WIDTH FOR TRACKED VEHICLES |
|---|---|---|
| Isolated vehicles of appropriate width only and in one direction only | At least 3.5M (11.5 ft) | At least 4M (13 ft) |
| Generally one way only; no overtaking or passing in opposite direction | 3.5M to 5.5M (11.5 ft to 18 ft) | 4M to 6M (13 ft to 19.5 ft) |
| Single flow | 5.5M to 7.3M (18 ft to 24 ft) | 6M to 8M (19.5 ft to 26 ft) |
| Double flow | Over 7.3M (24 ft) | Over 8M (26 ft) |

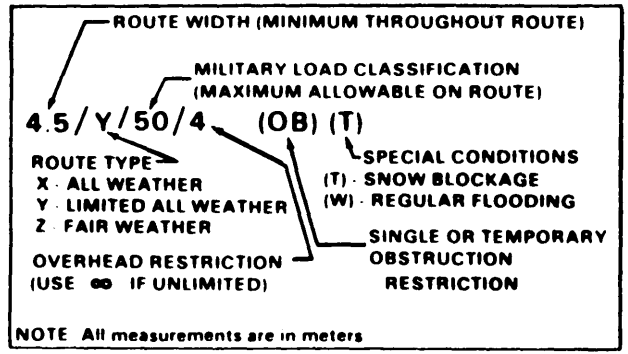



Figure 5-1. Route classification formula

### Slopes and Radius Computation

See Figures 5-2 and 5-3 (page 5-2)

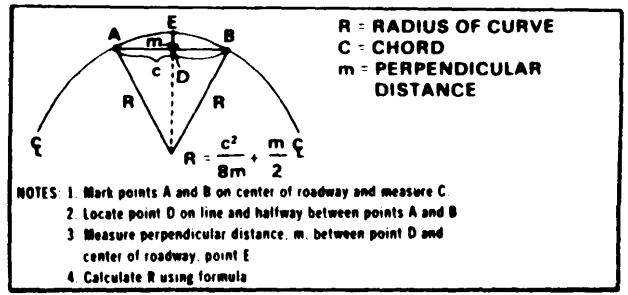



Figure 5-2. Radius of curvature calculation



[redacted]

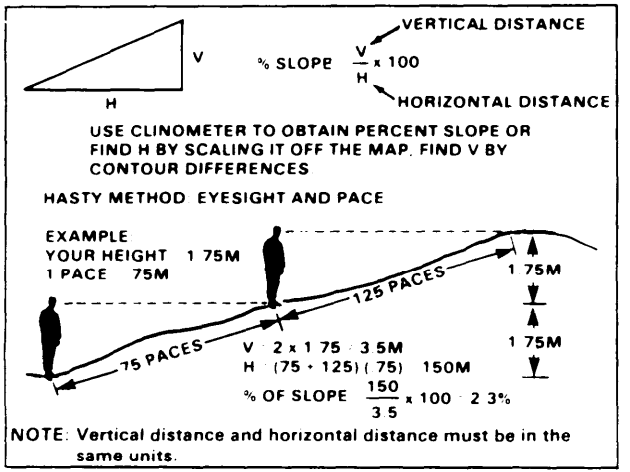



Figure 5-3. Slope computation (road gradient)

### Obstruction (OB)

The obstructions are any factors which restrict type, amount, or sped of traffic flow. Whenever (OB) appears in the route formula, the exact nature must be shown on the overlay. The most common obstruction are—

- Overhead clearance less than 4.3 meters (14 feet).
- Width below minimum standard prescribed for the type of traffic in Table 5-1.
- Slopes of 7 percent or greater and curves with 25-meter (82 foot) radius or less (Refer to the end of this chapter for overlay symbols and details).
- Fords ferries and all tunnels that do not meet the criteria in Table 5-1 or the minimum overhead clearance is less than 4.3 meters (14 feet).

### Report and Overlay

The report consists of an overlay specific features reconnaissance reports (bridge, ford, or road), and any other supplementary overlays reports, or sketches to support the route report. Figure 5-4 shows an example of a route reconnaissance overlay. (Refer to the end of this chapter for the appropriate symbols used on the overlay.)

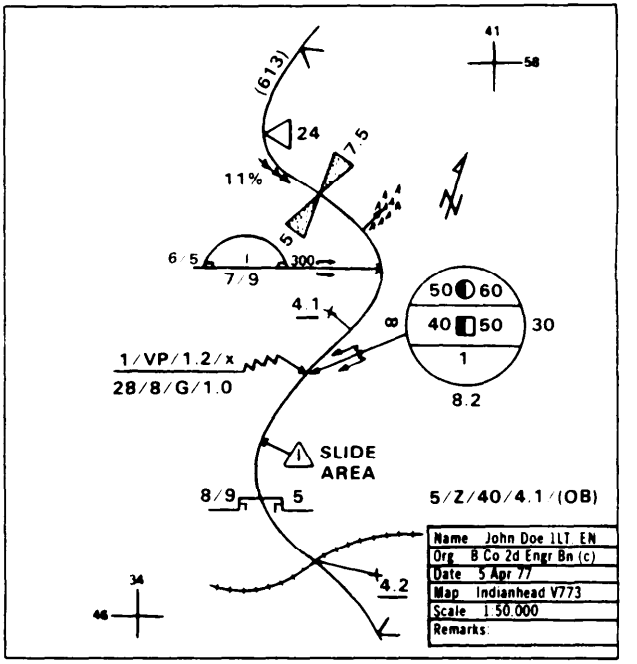



Figure 5-4. Route reconnaissance overlay

## ROAD RECONNAISSANCE

### Classification

Road classification is expressed in a standardized sequence prefix (A - no limiting characteristics or B some limiting characteristics), limiting characteristics (Table 5.2), traveled way width/traveled way plus shoulder width road surface material (Table 5.3), road length enclosed in parentheses, obstructions, and special conditions (Figure 5-1).

**Table 5-2. Road limiting characteristics and symbols**

| LIMITING CHARACTERISTICS | SYMBOL |
|---|---|
| Curves (radius 25 meters (82 feet) or less) | c |
| Gradients (seven percent or greater) | g |
| Drainage (inadequate ditches, culverts) | d |
| Foundation (unstable) | f |
| Surface condition (bumby, rutted, or potholed) | s |
| Camber or superelevation (excessive crown) | j |
| Unknown characteristics (used with other above symbols enclosed in parenthesis) Example: (c?) = unknown radius | ? |

All reports will be submitted in metric measurements

**Table 5-3. Road surface materials and symbols**

| SURFACE MATERIAL | SYMBOL |
|---|---|
| Concrete | k |
| Bituminous or asphaltic concrete (bituminous plant mix) | kb |
| Bituminous surface treatment on natural earth, stabilized soil sand-clay, or other select material | nb |
| Used when type of bituminous construction cannot be determined | b |
| Bituminous surface on paving brick, or stone | pb |
| Bitumen-penetrated macadam, water-bound macadam with superficial asphalt or tar cover | rb |
| Pavement, brick, or stone | p |
| Water-bound macadam, crushed rock, or coral | r |
| Gravel | l |
| Natural earth, stabilized soil, sand-clay, shell, cinders, disintegrated granite, or other select material | n |
| Various other types not mentioned above (indicate length when this symbol is used) | v |

**EXAMPLE.** Bcgd(f?)s 3.2/4.8 nb (4.3 km) (OB) (T). Road has limits of sharp curves, steep grades, bad drainage, unknown foundation, and rough surface; the traveled way width is 3.2 meters, combined width and shoulders is 4.8 meters. Surface material is bituminous surface treatment on natural earth stabilized soil, sand-clay, or other selected material. The road is 4. 3 kilometers long, contains obstructions, and is subject to snow blockage.

## Recording

Road reconnaissance data is recorded on DA Form 1248 (Road Reconnaissance Report) as shown in Figures 5-5 and 5-6

**ROAD RECONNAISSANCE REPORT**

DATE: 29 Aug 84

TO: Cdr. ATTN: S-2, 21st Engr Bn

FROM: DOE, JOHN, 1LT, Co A 522nd Eng

MAP: Ft Belvoir Special 1:50,000

SHEET NUMBER & SERIES: AMS V733 Sheet 5561 IV

DATE TIME GROUP (and signature): 291430Z AUG 84

**SECTION I - GENERAL ROAD INFORMATION**

1. ROAD GRID REFERENCE: FROM UT 122864 TO UT 097999
2. ROAD MARKING (Written or Military number of road): Virginia Route 617
3. LENGTH OF ROAD (Miles or Kilometers, specify): 16 Km
4. WIDTH OF ROADWAY (Feet or meters, specify): 6.7m to 9.3m
5. WEATHER DURING RECONNAISSANCE (Include last rainfall, if known): FAIR - Temp 79° Last Rainfall - 15 Aug. 84
6. RECONNAISSANCE: DATE 29 Aug 84 TIME 0615

**SECTION II - DETAILED ROAD INFORMATION** (When circumstances permit more detailed information will be shown in an overlay or on the mileage chart on the reverse side of this form. Standard symbols will be used.)

9. ALINEMENT (Check one ONLY)
   - (1) FLAT GRADIENTS AND EASY CURVES
   - (2) STEEP GRADIENTS (Excess of 7 in 100)
   - (3) SHARP CURVES (Radius less than 100 to 150m)
   - ✓ (4) STEEP GRADIENTS AND SHARP CURVES
10. DRAINAGE (Check one ONLY)
   - (1) ADEQUATE DITCHES, CROWN, CAMBER WITH ADEQUATE CULVERTS IN GOOD CONDITION
   - ✓ (2) INADEQUATE DITCHES, CROWN, CAMBER OR CULVERTS OR CULVERTS OR DITCHES ARE BLOCKED OR OTHER WISE IN POOR CONDITION
11. FOUNDATION (Check one ONLY)
   - ✓ (1) STABILIZED COMPACT MATERIAL OF GOOD QUALITY
   - (2) UNSTABLE, LOOSE OR EASILY DISPLACED MATERIAL
12. SURFACE DESCRIPTION (Complete items 12a and b)

a. THE SURFACE IS (Check one ONLY)
   - ✓ (1) FREE OF POTHOLES, BUMPS OR RUTS LIKELY TO REDUCE CONVOY SPEED
   - (2) BUMPY, RUTTED OR POTHOLED TO AN EXTENT LIKELY TO REDUCE CONVOY SPEED

b. TYPE OF SURFACE (Check one ONLY)
   - (1) CONCRETE
   - ✓ (2) BITUMINOUS (Specify type where known): Asphalt
   - (3) BRICK (Pave)
   - (4) STONE (Pave)
   - (5) CRUSHED ROCK OR CORAL
   - (6) WATERBOUND MACADAM
   - (7) GRAVEL
   - (8) LIGHTLY METALLED
   - (9) NATURAL OR STABILIZED SOIL, SAND, CLAY, SHELL, CINDERS, DISINTEGRATED GRANITE OR OTHER SELECTED MATERIAL
   - (10) OTHER (Describe)

**SECTION III - OBSTRUCTIONS** (List in the column below particulars of the following obstructions which affect the traffic capacity of a road. If information of any factor cannot be ascertained, insert "NOT KNOWN")

(a) Overhead obstructions, less than [illegible] feet or [illegible] meters, such as tunnels, bridges, overhead wires and overhanging buildings
(b) Reductions in road width which limit the traffic capacity, such as craters, narrow bridges, archways, and buildings
(c) Excessive gradients (Above 7 in 100)
(d) Curves less than [illegible] in radius
(e) Fords 82.5m (25mx2.1)

| SERIAL NUMBER a | PARTICULARS b | GRID REFERENCE c | REMARKS d |
|---|---|---|---|
| | Steep Grade - 8% | UT119872 | 200m long |
| | Sharp Curve | UT112877 | Radius 21m |
| | Constriction | UT112878 | 6.7m wide, 300m long |
| | Constriction | UT105896 | 7m wide, 100m long |
| | Built Up Area | UT094856 | 7.3m wide 2000 Long |
| | | | |
| | | | |
| | | | |

DA FORM 1248

Figure 5-5 Road reconnaissance report (front)

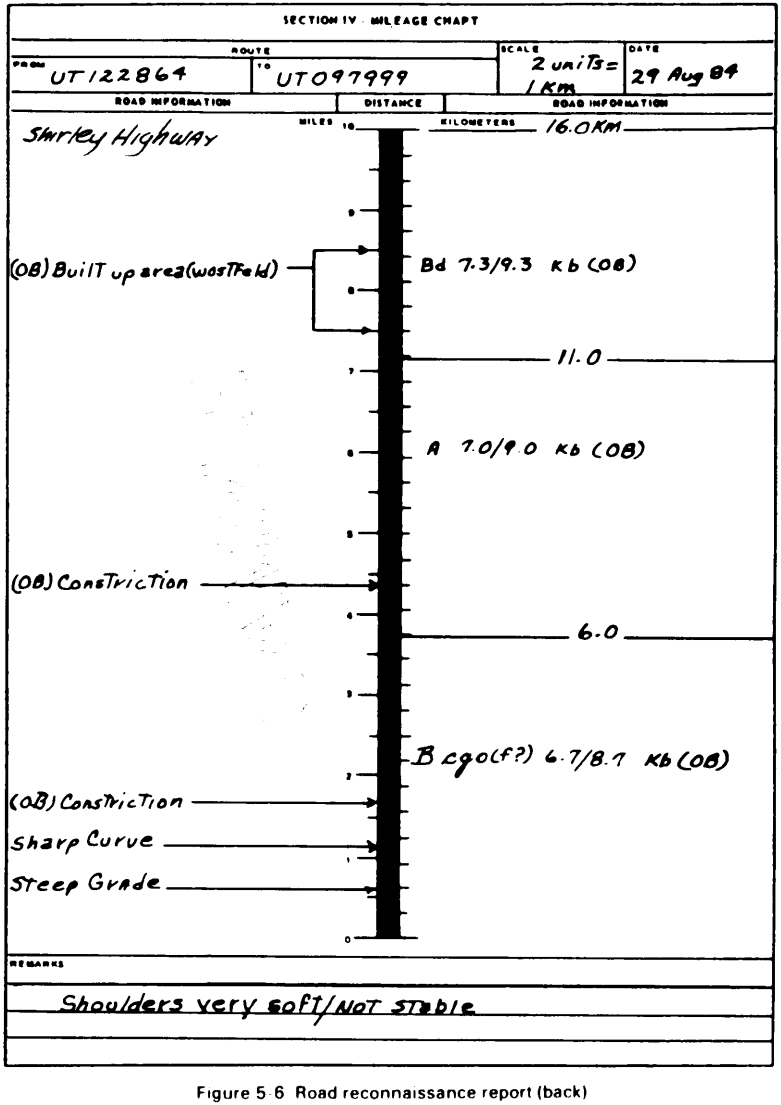



Figure 5-6 Road reconnaissance report (back)

## BRIDGE RECONNAISSANCE

### Hasty

To make an immediate crossing use Tables 5-4 and 5-5 to determine a hasty bridge classification When a bridge shows any sign of damage or if a permanent classification is desired, a qualified engineer should determine the allowable load classification using TM 5 312.

### Deliberate

In order to accurately classify a bridge or prepare a bridge for demolition a detailed reconnaissance must be accomplished . Use DA Form 1249( Bridge Reconnaissance Report), Table 5-6, and Figures 5-7 through 5-13 to record the needed data. Table 5-6 may be used as a guide for developing a line-number report format for voice or digital transmission of bridge data. The obtained information is used in conjunction with TM 5-312 for classification.

**Table 5-5. Minimum bridge criteria**

| BRIDGE CLASSIFICATION | MINIMUM WIDTH BETWEEN CURBS ONE LANE M (FT) | TWO LANE M (FT) |
|---|---|---|
| 4-12 | 2.75 (9) | 5.50 (18) |
| 13-30 | 3.35 (11) | 5.50 (18) |
| 31-60 | 4.00 (13) | 7.30 (24) |
| 61-100 | 4.50 (15) | 8.20 (27) |
| 101-150 | 5.0 (17) | 9.8 (32) |
| | MINIMUM OVERHEAD CLEARANCE M (FT) | |
| All classes | 4.5 (15) | |

**Table 5-4. Hasty bridge classification**

| PRIVATE ROAD | | | | | STATE OR COUNTY ROAD | | | | | | | US OR INTERSTATE HIGHWAY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PRIME USERS | | | | | RESTRICTIONS | | | | | | | |
| CARS | FARM | TRUCKS | | | NONE | | LOAD WEIGHT | WIDTH | | | AXLE LOAD | |
| 4 | 16 | Axles | | | Bridge Date | | MLC= max load limit up to 30 tons | Less than 6 ft | 6 ft to 8 ft | 8 ft to 10 ft | MLC= Axle Load X 2.5 | 70 / 100 |
| | | 2 | 3 | 4/5 | Pre-1960 | Post-1960 | | | | | | 60 / 70 |
| | | 20 | 24 | 30 | 30 | 30 (min) Use correlation curves for higher class | | 8 | 16 | 24 | | |

Table 5-6. Dimensions required on the seven basic bridges

| DIMENSIONS REQUIRED TO COMPLETE FRONT SIDE OF DA 1249 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NUMBER ON FIGURE | DIMENSION DATA | SIMPLE STRINGER (FIGURE 5-7) | SLAB (FIGURE 5-8) | T-BEAM (FIGURE 5-8) | TRUSs (FIGURE 5-9) | GIRDER (FIGURE 5-10) | ARCH (FIGURE 5-11) | SUSPENSION (FIGURE 5-12) |
| 1 | Overall length | x | x | x | x | x | x | x |
| 2 | Number of spans | x | x | x | x | x | x | x |
| 2 | Length of spans | x | x | x | x | x | x | x |
| 2a | Panel length | | | | x | | | x |
| 3 | Height above streambed | x | x | x | x | x | x | x |
| 3a | Height above estimated normal water level | x | x | x | x | x | x | x |
| 4 | Traveled way width | x | x | x | x | x | x | x |
| 5 | Overhead clearance | | | | x | | | x |
| 6 | Horizontal clearance | x | x | x | x | x | x | x |

THIS TABLE SHOWS THE MEASUREMENTS REQUIRED TO REPORT THE SEVEN BASIC TYPES Of BRIDGES. FIGURES 5-7 THROUGH 5-15 SHOW WHERE TO TAKE THESE MEASUREMENTS.

Table 5-6. Dimensions required on the seven basic bridges (continued)

| DIMENSIONS REQUIRED TO COMPLETE BACK OF DA 1249 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LETTER DESIGNATION | CAPACITY [a] DIMENSION DATA | SIMPLE STRINGER (FIGURE 5-7) | | | | | SLAB (FIGURE 5-8) | T-BEAM (FIGURE 5-8) | TRUSS (FIGURE 5-9) | GIRDER (FIGURE 5-10) | ARCH (FIGURE 5-11) | SUSPENSION (FIGURE 5-12) |
| a | Thickness of wearing surface | x | | | | | x | x | x | x | x | x |
| b | Thickness of flooring, deck, or depth of fill at crown | x | | | | | x | x | x | x | x | x |
| | | TIMBER | | STEEL | | | | | | | | |
| | | RECTANGLE | LOG | I-BEAM | CHANNEL | RAIL | | | | | | |
| c | Distance, c-to-c, between T-beams, stringers, or floor beams | x | x | x | x | x | | x | x | x | x | x |
| d | Number of T-beams or stringers | x | x | x | x | x | | x | x | x | | x |
| e | Depth of each T-beam or stringer | x | (b) | x | x | x | | x | x | x | | x |
| f | Width of each T-beam or stringer | x | | (c) | (c) | (c) | | x | x | x | | x |
| g | Thickness of web of I-beams, WF-beams, channels, or rails | | | x | x | x | | | x | x | | x |
| h | Sag of cable | | | | | | | | | | | x |
| i | Number of each size of cable | | | | | | | | | | | x |
| j | Thickness of arch ring | | | | | | | | | | x | |
| k | Rise of arch | | | | | | | | | | x | |
| l | Diameter of each size of cable | | | | | | | | | | | x |
| m | Depth of plate girder | | | | | | | | | x | | |
| n | Width of flange plates | | | | | | | | | x | | |
| o | Thickness of flange plates | | | | | | | | | x | | |
| p | Number of flange plates | | | | | | | | | x | | |
| q | Depth of flange angle | | | | | | | | | x | | |
| r | Width of flange angle | | | | | | | | | x | | |
| s | Thickness of flange angle | | | | | | | | | x | | |
| t | Depth of web plate | | | | | | | | | x | | |
| u | Thickness of web plate | | | | | | | | | x | | |
| v | Average thickness of flange | | | x | | | | | | | | |
| w | Depth of cover | | | | | | | | | | x | |

The letter "x" indicates that the dimension is required

[a] Capacity is computed by the use of formulas and data outlined in TM 5-312

[b] Diameter

[c] Width of flange

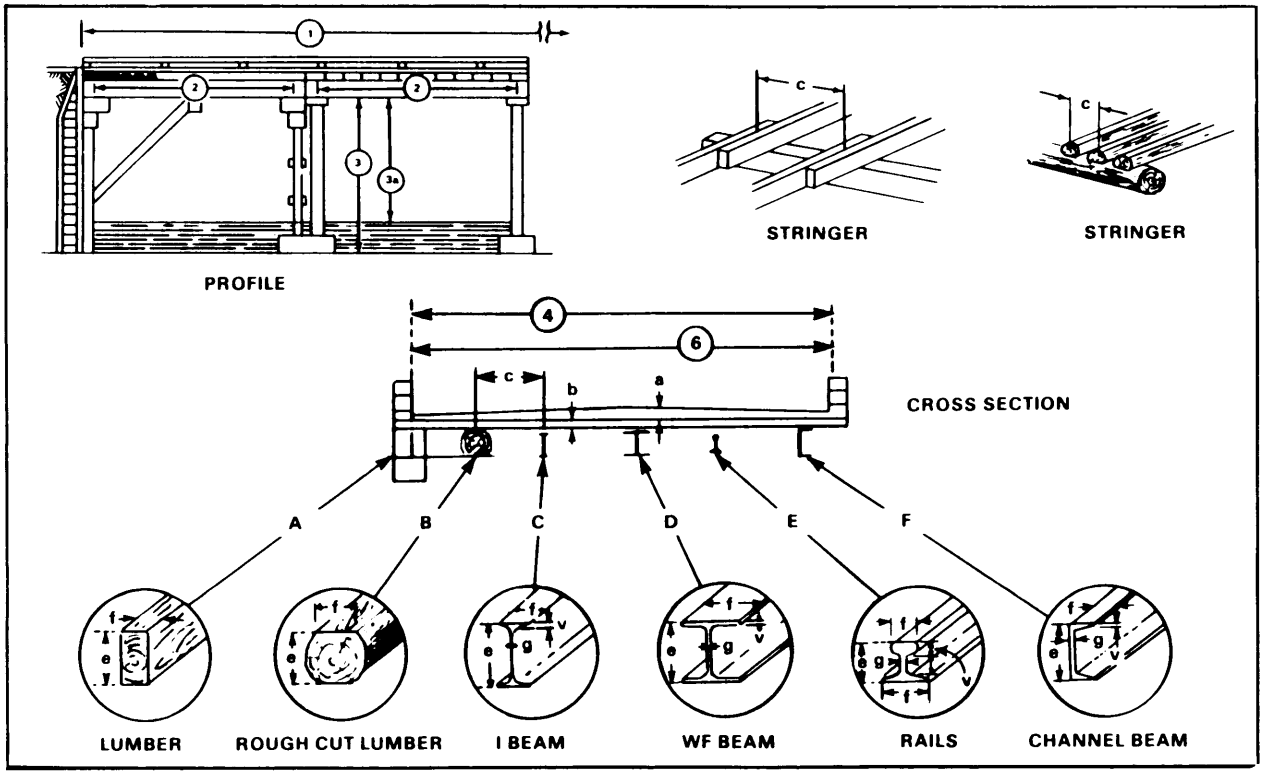



Figure 5-7. Dimensions required to report simple stringer bridges

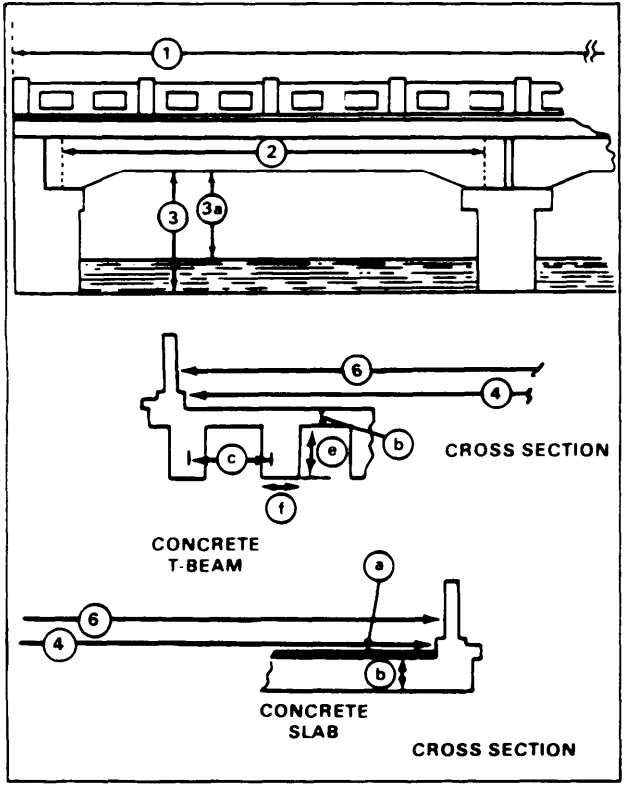



Figure 5-8. Dimensions required to report concrete bridges

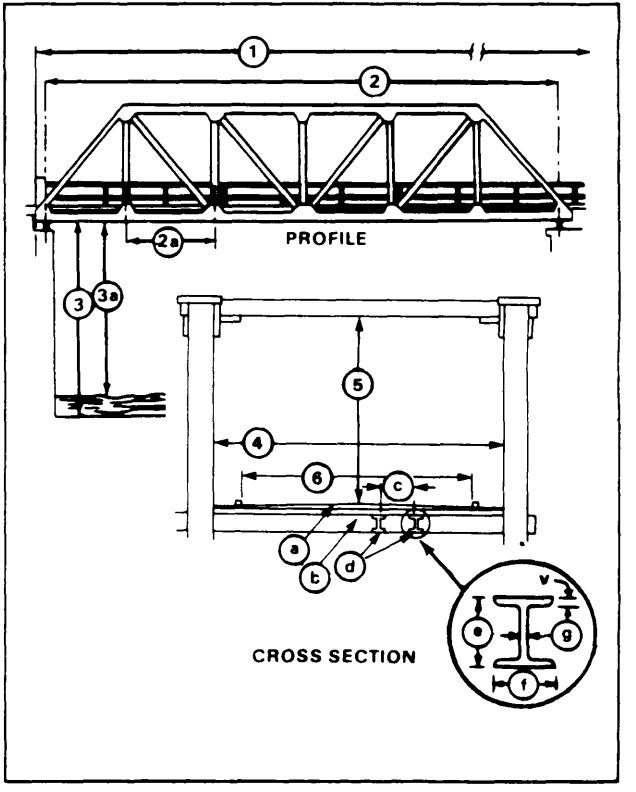



Figure 5-9. Dimensions required to report steel truss bridges

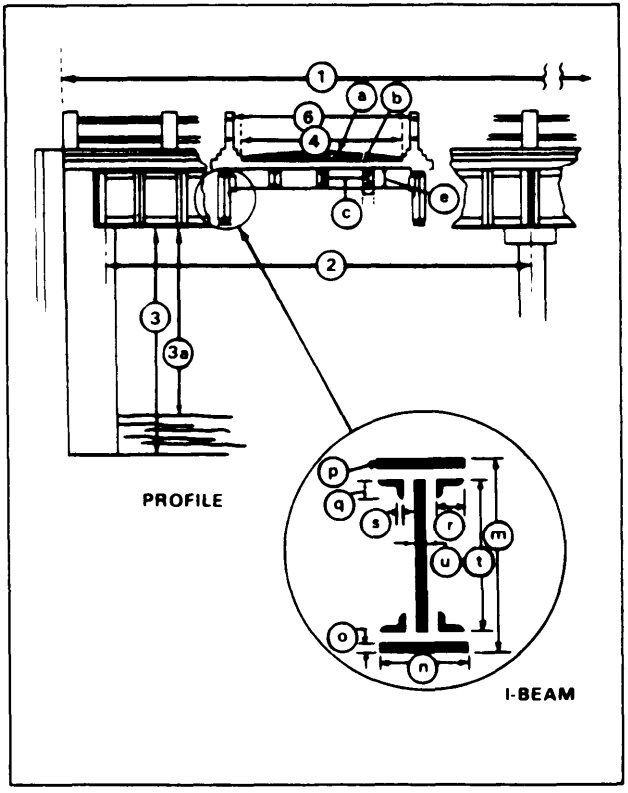



Figure 5-10. Dlmensions required to report plate girder bridges

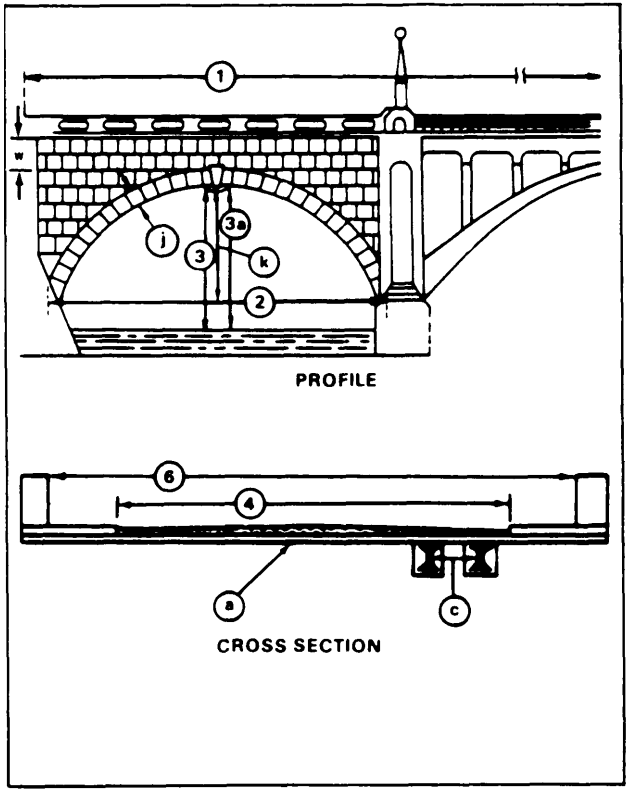



Figure 5-11. Dimensions required to report arch bridges

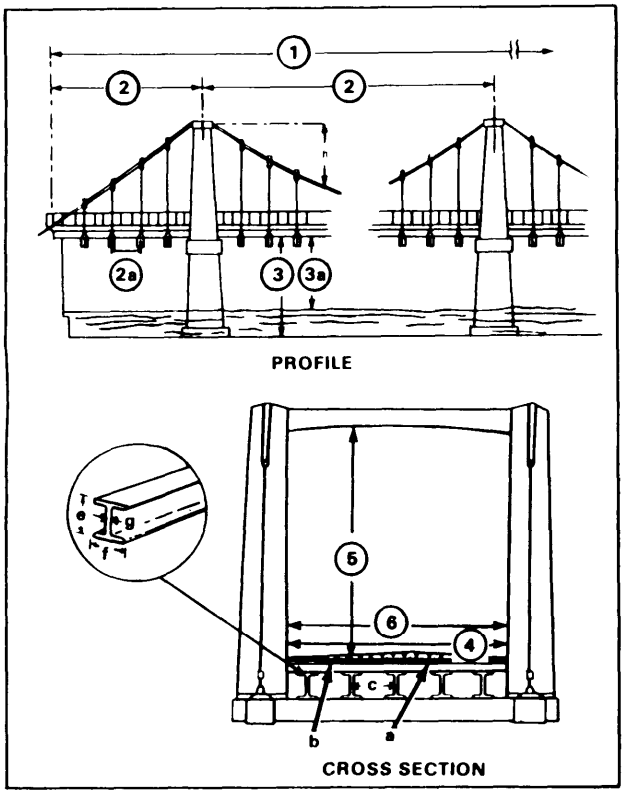



Figure 5-12. Dimensions required to report suspension bridges

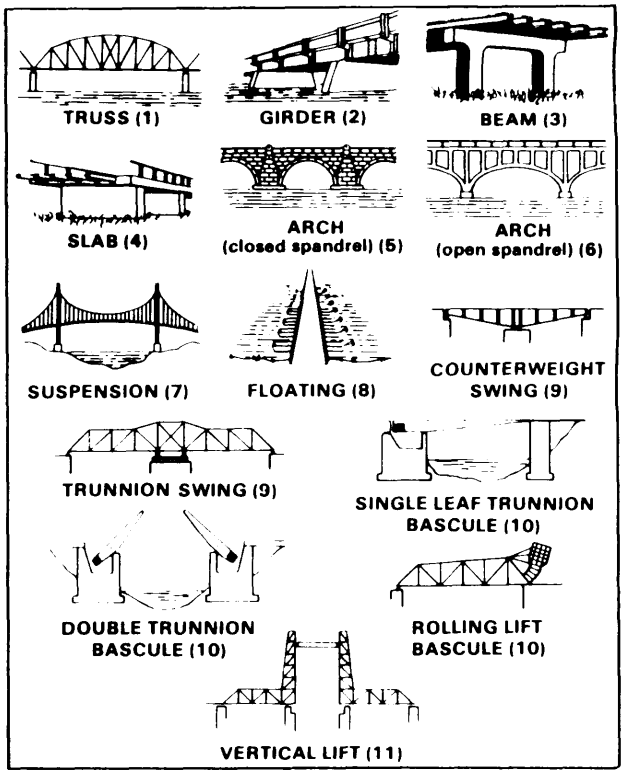



Figure 5-13. Span types and construction material used for completing DA Form 1249

Report

To send bridge reconnaissance information, complete a DA Form 1249 (Figures 5-14 and 5-15, page 5-14). Use Table 5-6 (pages 5-7 and 5-8) to ensure that all requirements are covered.

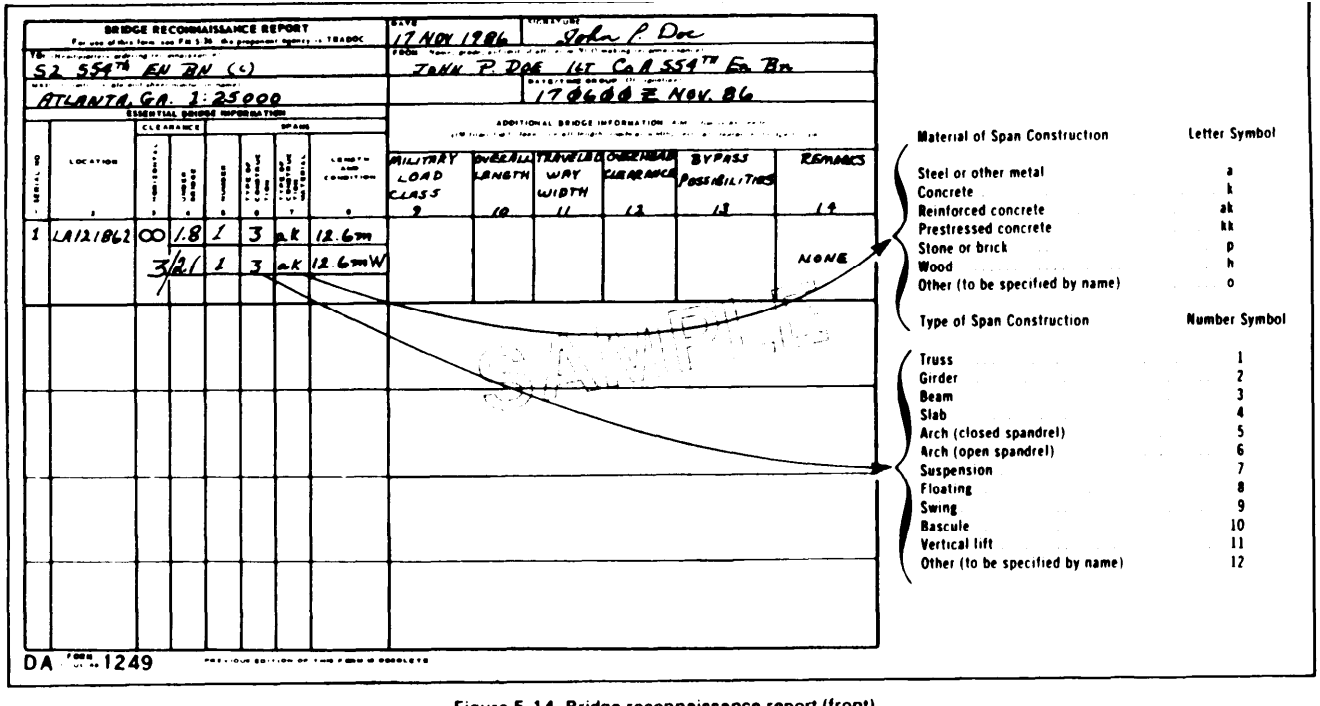



Figure 5-14. Bridge reconnaissance report (front)

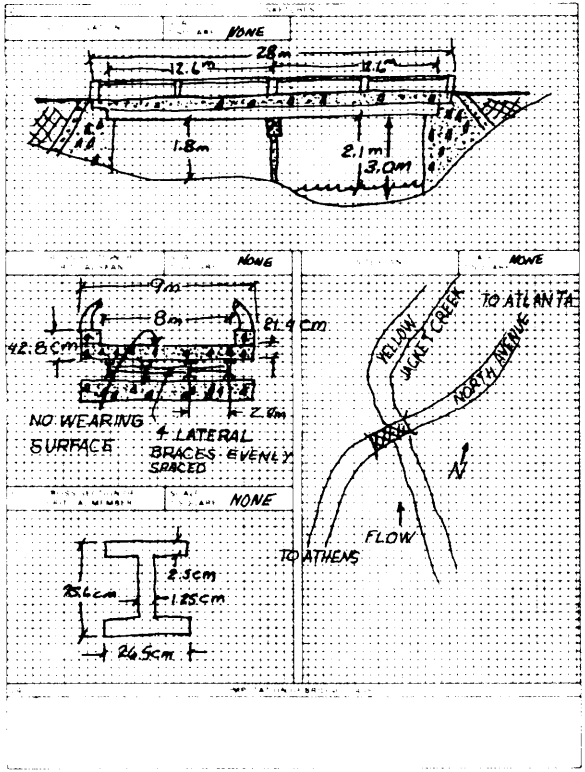
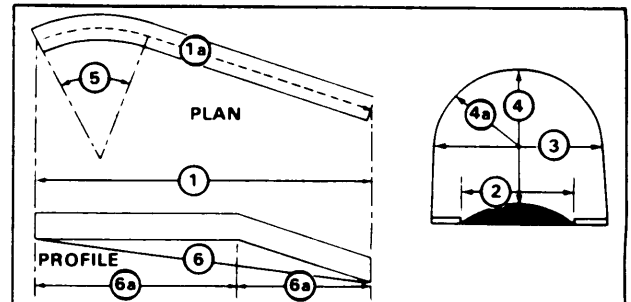



**Figure 5-15. Bridge reconnaissance report (back)**

## TUNNEL RECONNAISSANCE

Refer to Table 5-1 (page 5-1) for roadway width requirements. Overhead clearances less than 43 meters are classified as obstructions. Complete the DA Form 1250 (Tunnel Reconnaissance Report) in accordance with the bridge reconnaissance report. Figure 5-16 shows a typical sketch of a tunnel with minimum required dimensions.




1 Portal-to-portal length of tunnel.
1a Centerline distance of tunnel.
2 Effective width of the traveled way, curb to curb.
3 Horizontal clearance (minimum width of the tunnel bore measured at least 4 feet above the traveled way).
4 Overhead clearance (minimum distance between the top of the traveled way and the lower edge of the tunnel ceiling or any obstruction below the ceiling such as trolley wires or electric light wires).
4a Rise of tunnel arch (radius of curved portion).
5 Radius of curvature of the traveled way either measured or estimated.
6 Gradient (percentage of rise of the traveled way between portals).
6a Change in gradient within the tunnel (percentage of rise each way from break of grade).

**Figure 5-16. Typical tunnel sketch with required measurements**

## WATER-CROSSING RECONNAISSANCE

All water-crossing reconnaissance, such as swim, ford, raft, bridge, and ferry, include the following factors:

### Road Network

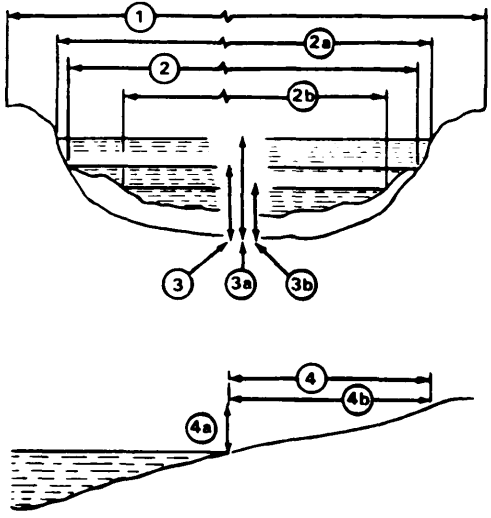
The road network should support the largest vehicles and have good drainage facilities.

### Avenues To and From the River

The avenues should be straight for at least 150 meters, have a 10 percent maximum grade, have two lanes with a turnaround, and have all-weather surface whenever possible.

### Riverbanks

The riverbanks should have stability, slope, and height as shown in Figure 5-17.




1. The width of streambed from bank to bank.
2. The actual width of the water, measured at normal stage (maximum width 2a and minimum width 2b are estimated, based on local observations or records of high water and low water).
3. The actual depth of the stream at normal water level.

3a. Estimated maximum water depth based on local observations or records.

3b. Estimated minimum water depth based on local observations (watermarks) or records.

4. The slope of the approaches is the slope of the stream banks through which the approach roads are cut.

$$\% \text{ Slope} = \frac{4a}{4b} \times 100$$

4a = Approach elevation.

4b = Approach distance.

Figure 5-17. River or stream measurements

### Widths

Measure the widths by using a string or tape across the river scaled off the map, or as shown in Figure 5-18.

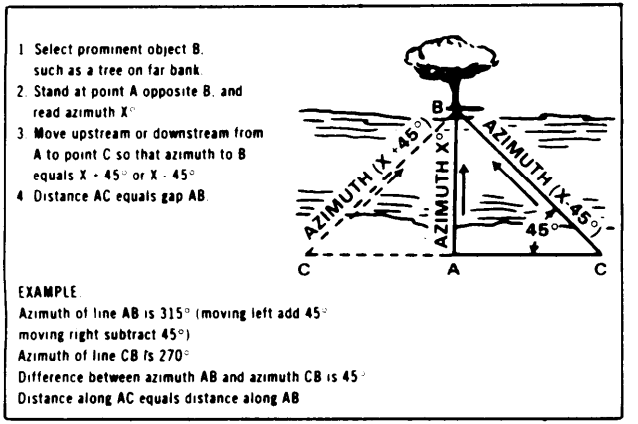



**Figure 5-18. Measuring stream width with a compass**

### Depths

Record the depths every 3 meters by using a measured pole/rod or weighted ropes/strings.

### Sites

Assembly areas and other needed areas should be spacious, provide good concealment, and have easy access routes.

### Velocity

Measure the velocity by using the procedures in Figure 5-19.

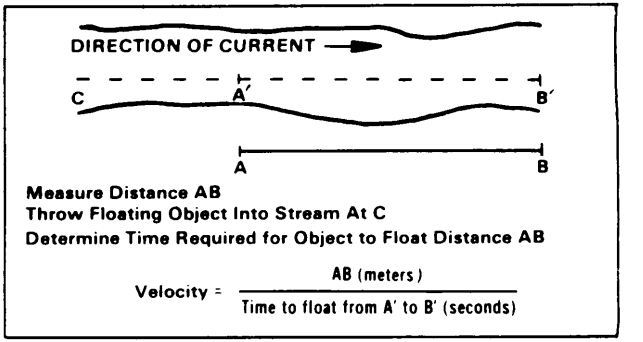



**Figure 5-19. Measuring stream velocity**

### Obstructions

Some obstructions are sandbars, floating debris, and other water obstacles or restrictions.

### Drainage

The drainage should be adequate.

### Soil Stability

The seal should be adequate for anchoraging. Check the banks and river bottoms for stability.

## FORD RECONNAISSANCE

Use Table 5-7 to determine trafficability. When DA Form 1251 (Ford Reconnaissance Report) is used for swim site, it must specify that the site is for swimming only.

Table 5-7. Trafficability of fords

| TYPE OF TRAFFIC | SHALLOW FORDABLE DEPTH IN METERS (INCHES) | MINIMUM WIDTH IN METERS | MAXIMUM PERCENT OF SLOPE FOR APPROACHES [1] |
|---|---|---|---|
| Foot | 1 (39) | 1 (39 in) (single file) 2 (79 in) (columns of 2) | 100% 1:1 |
| Trucks and truck-drawn artillery | .75 (30) | 3 6 (12 ft) | 33% 1:3 |
| Light tanks | 1 (39) | 4 2 (14 ft) | 50% 1:2 |
| Medium tanks [2] | 1.05 (42) | 4 2 (14 ft) | 50% 1:2 |

[1] Based on hard, dry surface

[2] Depths up to 4.3 meters can be negotiated with deep water fording kit

## ENGINEER RECONNAISSANCE

The engineer reconnaissance report consists of a completed DA Form 1711-R (Engineer Reconnaissance Report) and an engineer reconnaissance overlay (Figures 5-20 and 5-21 page 5-18). A reconnaissance checklist is provided in Table 5-8 When looking for water point locations select sites with running water if possible To determine the capacity of the water source in liters per minute use; the following formula:

$$Q = A \times V \; 48.000$$

Where Q = Flow in liters per minute

A = Cross section of stream flow in square meters

V = Meters per second

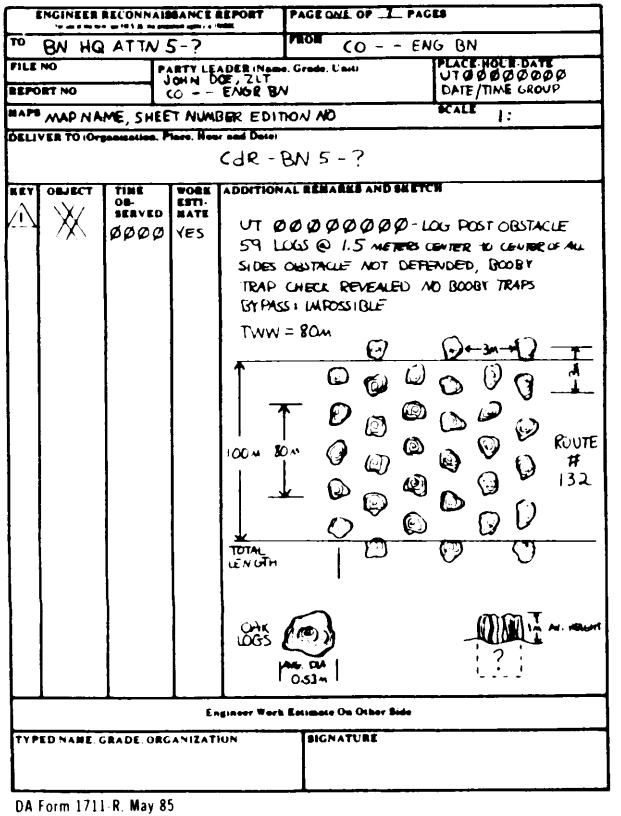
48,000 = Conversion and correction factor

Check the color, odor, turbidity, and taste (do not drink) of water. Report any possible pollution such as human or industrial waste, dead fish, and so forth. Overlay symbols are shown on pages 5-19 through 5-21 and material facility equipment and service symbols are shown in Figure 5-22.

Table 5-8. Engineer reconnaissance checklist

- ☐ ROADS. Classify using symbols.
- ☐ BRIDGES, FORDS, AND FERRIES. Classify using symbols and include possible bypass for existing crossings.
- ☐ OBSTACLES TO MOVEMENT. Report natural and artificial obstacles including demolitions, mines, and booby traps.
- ☐ TERRAIN. Report general nature, ridge system, drainage system including fordability, forests, swamps, and areas suitable for mechanized operations.
- ☐ ENGINEER MATERIALS. Report road material, bridge timbers, lumber, steel, and explosives.
- ☐ ENGINEER EQUIPMENT. Record data on rock crushers, sawmills, garages, machine shops, blacksmith shops, or other facilities or equipment.
- ☐ ERRORS AND OMISSIONS ON MAPS USED.
- ☐ WATER POINTS. Recommend locations.
- ☐ BARRIERS TO ENEMY MOVEMENT. Describe natural, or artificial barriers and sites for construction of improvement (work estimates).
- ☐ STREAMS. Give a general description of width, depth, banks, approaches, character of bottom, navigability, and possible ways to cross.
- ☐ DEFENSIVE POSITIONS.
- ☐ BIVOUAC AREAS. Give data on entrances, soil, drainage, sanitation, and concealment.
- ☐ PETROLEUM STORAGE AND EQUIPMENT.
- ☐ UTILITIES. Report water, sewage, electricity, and gas utilities available.
- ☐ PORTS. Show wharves, sunken obstacles, cargo handling facilities, storage facilities, and transportation routes.
- ☐ CONSTRUCTION SITES. Report drainage, water supply, power source, earthwork, access, acreage, and soil conditions.
- ☐ ANY OTHER INFORMATION OF IMPORTANCE.

NOTE: Give work estimates as required.



ENGINEER RECONNAISSANCE REPORT

PAGE ONE OF 1 PAGES

TO: BN HQ ATTN 5-?

FROM: CO - - ENG BN

FILE NO:

REPORT NO:

PARTY LEADER (Name, Grade, Unit): JOHN DOE, 2LT, CO - - ENGR BN

PLACE-HOUR-DATE: UTØØØØØØØØ DATE/TIME GROUP

MAPS: MAP NAME, SHEET NUMBER EDITION NO

SCALE: 1:

DELIVER TO (Organization, Place, Hour and Date): CdR - BN 5 - ?

| KEY | OBJECT | TIME OBSERVED | WORK ESTIMATE | ADDITIONAL REMARKS AND SKETCH |
|---|---|---|---|---|
| 1 | | ØØØØ | YES | UT ØØØØØØØØ - LOG POST OBSTACLE 59 LOGS @ 1.5 METERS CENTER TO CENTER OF ALL SIDES OBSTACLE NOT DEFENDED, BOOBY TRAP CHECK REVEALED NO BOOBY TRAPS BYPASS: IMPOSSIBLE TWW = 80m |



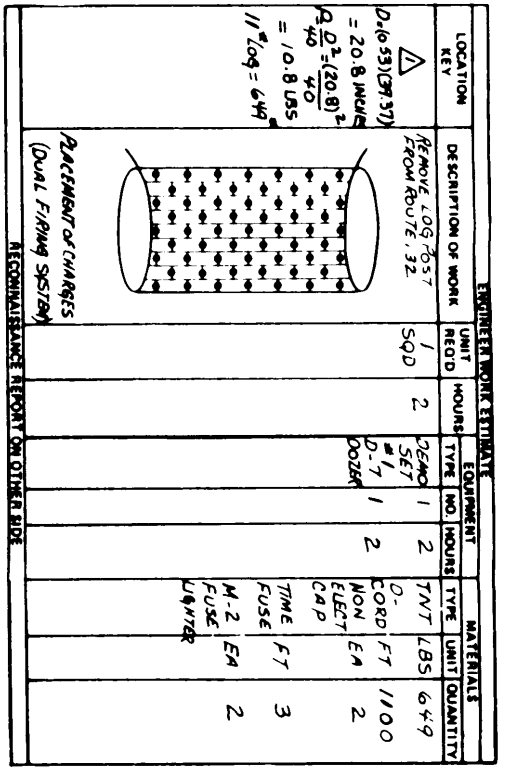
Engineer Work Estimate On Other Side

TYPED NAME, GRADE, ORGANIZATION

SIGNATURE

DA Form 1711-R, May 85

Figure 5-20. Sample engineer reconnaissance report (front)



ENGINEER WORK ESTIMATE

| LOCATION KEY | DESCRIPTION OF WORK | UNIT REQ'D | HOURS | EQUIPMENT TYPE | EQUIPMENT NO. | EQUIPMENT HOURS | MATERIALS TYPE | MATERIALS UNIT | MATERIALS QUANTITY |
|---|---|---|---|---|---|---|---|---|---|
| 1 | REMOVE LOG POST FROM ROUTE, 32 | 1 SQD | 2 | DEMO SET #1 | 1 | 2 | TNT | LBS | 649 |
| | | | | D-7 DOZER | 1 | 2 | D-CORD | FT | 1100 |
| | | | | | | | NON ELECT CAP | EA | 2 |
| | | | | | | | TIME FUSE | FT | 3 |
| | | | | | | | M-2 FUSE LIGHTER | EA | 2 |

$D = (0.53)(39.37) = 20.8$ INCHES

$P = \frac{D^2}{40} = \frac{(20.8)^2}{40} = 10.8$ LBS

$11^{\#}$ LOG = 649#

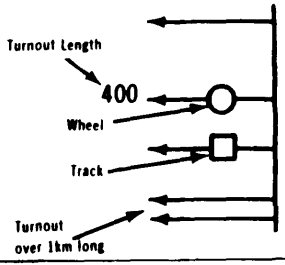
PLACEMENT OF CHARGES (DUAL FIRING SYSTEM)

RECONNAISSANCE REPORT ON OTHER SIDE

Figure 5-21. Sample engineer reconnaissance report (back)

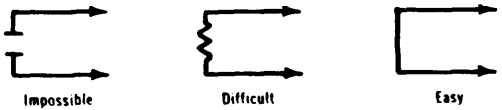
## OVERLAY SYMBOLS

### TURNOUTS

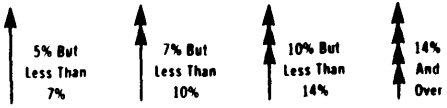



Arrows are drawn at location of turnout, pointing to the turnout direction.

### BYPASSES

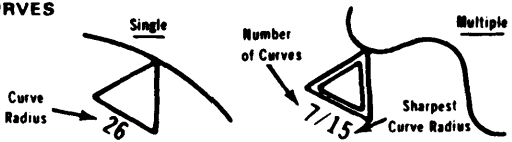



### GRADES




### OBSTACLES

### CURVES



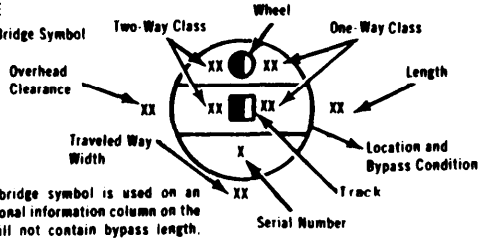

Sharp curve: Any curve with radius of 25 meters or less is an obstruction.
All curves with radius less than 45 meters are reportable.

### CRITICAL POINT

Number, in order, and describe on DA Form 1711-R.

### BRIDGE

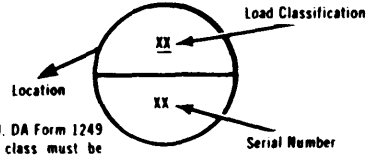
Full NATO Bridge Symbol




When full NATO bridge symbol is used on an overlay, the additional information column on the DA Form 1249 will not contain bypass length, traveled way width, or overhead clearance.

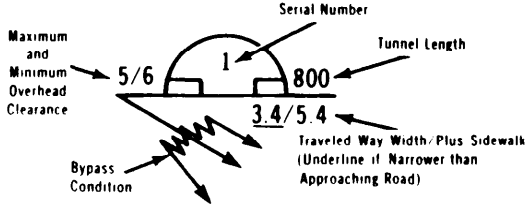
### BRIDGE

Abbreviated Bridge Symbol

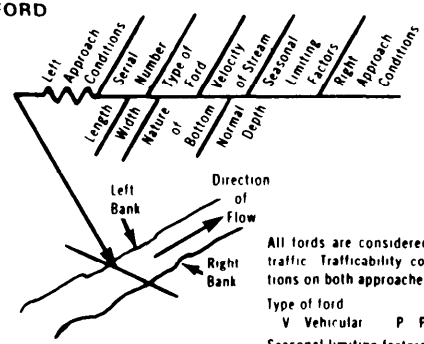



When abbreviated symbol is used, DA Form 1249 must be attached. Bridge load class must be underlined if traveled way width is below the standards on Table 5-5.

## TUNNEL




## FORD




All fords are considered as obstruction (OB) to traffic. Trafficability conditions indicate conditions on both approaches

Type of ford
V Vehicular P Pedestrian

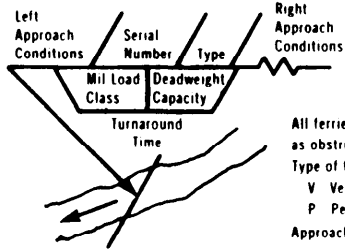
Seasonal limiting factors
X No seasonal limitation except for limited duration after sudden flooding
Y Significant seasonal limitations

Nature of bottom
M Mud C Clay S Sand
G Gravel R Rock P Artificial paving

Approach conditions
Difficult — Easy

NOTE. See Table 5-7 (page 5-17).

## FERRY

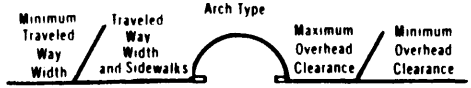



All ferries are considered as obstructions (OB) to traffic

Type of ferry
V Vehicular
P Pedestrian

Approach conditions
Difficult — Easy

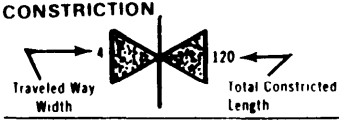
## UNDERPASS




If traveled way width is narrower than width of road leading into tunnel, the number must be underlined

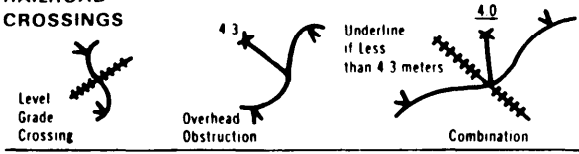
Symbol is drawn to show shape of structure. Show sidewalk when present. If clearance is less than 4.3 meters, it is an obstruction

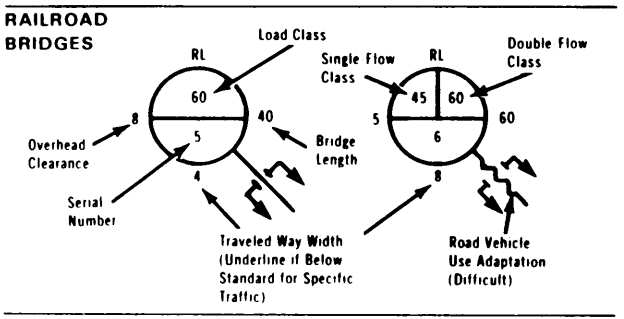
## CONSTRICTION




See Table 5.1 to determine if constriction is a traffic obstruction

## RAILROAD CROSSINGS





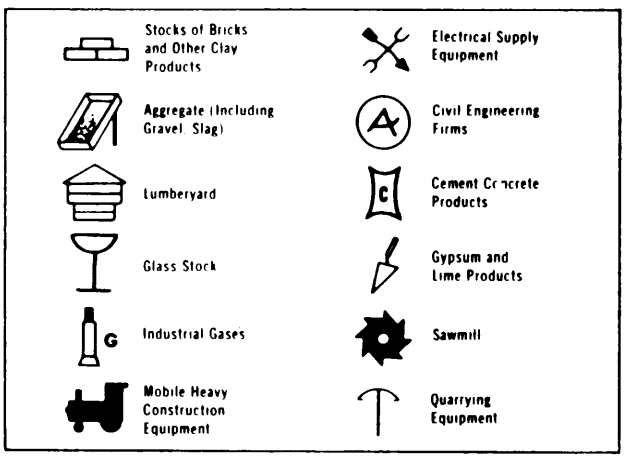




Figure 5-22. Material, facility equipment, and service symbols

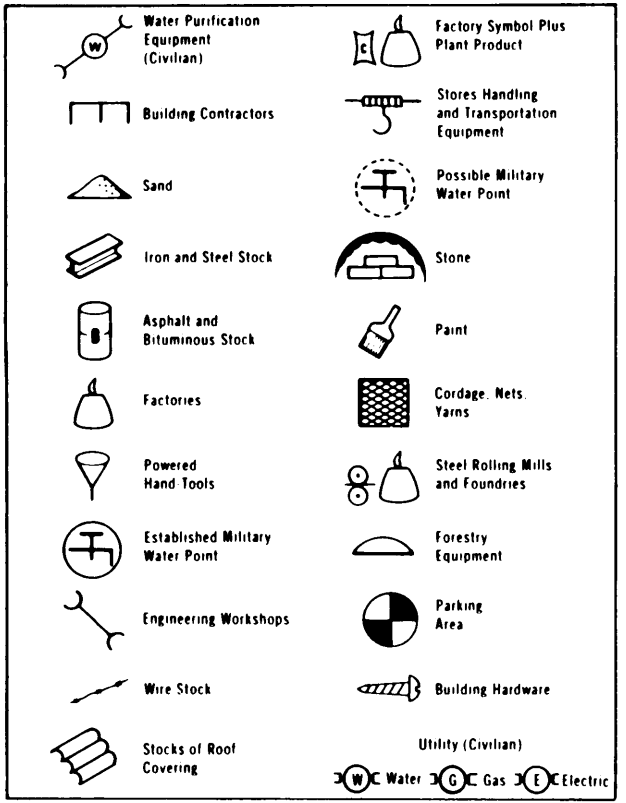



Figure 5-22. Material, facility equipment, and service symbols (continued)

## SAFETY

The minimum safe distances for personnel in the open when detonating explosives are given in Table 6-1.

**Table 6-1. Explosives minimum safe distances**

| EXPLOSIVES KG (LB) | SAFE DISTANCE, M (FT) | EXPLOSIVES KG (LB) | SAFE DISTANCE, M (FT) |
|---|---|---|---|
| .45 to 12.3 (1 to 27) | 300 (900) | 68.0 (150) | 534 (1,590) |
| 13.6 (30) | 311 (930) | 79.8 (175) | 560 (1,680) |
| 16.3 (35) | 327 (980) | 90.7 (200) | 585 (1,750) |
| 18.1 (40) | 342 (1,020) | 102.4 (225) | 609 (1,820) |
| 20.8 (45) | 356 (1,070) | 113.8 (250) | 630 (1,890) |
| 22.7 (50) | 369 (1,100) | 125.1 (275) | 651 (1,950) |
| 27.2 (60) | 392 (1,170) | 136.0 (300) | 670 (2,000) |
| 31.8 (70) | 413 (1,240) | 147.8 (325) | 688 (2,070) |
| 36.3 (80) | 431 (1,290) | 158.8 (350) | 705 (2,100) |
| 40.8 (90) | 449 (1,330) | 170.5 (375) | 722 (2,160) |
| 45.4 (100) | 465 (1,390) | 181.4 (400) | 737 (2,210) |
| 57.1 (125) | 500 (1,500) | 193.2 (425) | 750 (2,250) |
| | | 227.3 (500) | 800 (2,400) |

For charges over 227.30 kg (500 lb),

distance in feet = $300 \sqrt[3]{\text{Pounds of explosives}}$

Safe distance in meters = $100 \times \sqrt[3]{\text{Pounds of explosives}}$

Minimum distance of personnel in a missile-proof shelter is 91.4 m (300 ft)

Explosives may be prematurely detonated by induced currents. Table 6-2 gives distances that transmitters may detonate explosives by transmitted-induced currents.

**Table 6-2. Premature detonation by induced currents**

| MINIMUM SAFE DISTANCE FROM TRANSMITTER ANTENNAS | |
|---|---|
| AVERAGE OR PEAK TRANSMITTER POWER | MINIMUM DISTANCE TO TRANSMITTER |
| WATTS (NOTE) | M (FT) |
| 0-30 | 30 (96.4) |
| 30-50 | 50 (164.1) |
| 50-100 | 110 (360.9) |
| 100-250 | 160 (524.9) |
| 250-500 | 230 (754.6) |
| 500-1,000 | 305 (1,000.6) |
| 1,000-3,000 | 480 (1,574.8) |
| 3,000-5,000 | 610 (2,001.3) |
| 5,000-20,000 | 915 (3,001.9) |
| 20,000-50,000 | 1,530 (4,921.2) |
| 50,000-100,000 | 3,050 (9,824.1) |

NOTE: When the transmission is a pulsed or pulsed continuous wave type and its pulse width is less than 10 microseconds. The left hand column indicates average power for all other transmissions, including those with pulse widths greater than 10 microseconds. The left hand column indicates peak power.

Electric power lines. Electric firing should not be performed within 155 meters of energized power transmission lines. When it is necessary to conduct blasting operations at distances closer than 155 meters to electric power lines, nonelectric firing systems should be used or the power lines deenergized.

CAUTION: If electric blasting caps are to be transported near operating transmitters or in vehicles (including helicopters) in which a transmitter is to be operated, the caps will be placed in a metal can, the cover of which must be snug fitting and lap over the body of the can to a minimum depth of one-half inch. Caps will not be removed from container in proximity to operating transmitter unless the hazard has been evaluated and estimated to be acceptable (ammo can).

Misfires should be handled by the person who placed the charge. Thirty minutes must be allowed for "cook-off" on all nonelectric or buried charges. Above ground misfires should be blown in place by priming at least 1 pound of exploxive placed as close as possible to the charge without disturbing it. Buried misfires should be carefully excavated to no closer than 1 foot from charge and then blown in place with at least 2 pounds of explosive. Do not attempt to move or disarm a misfire and do not abandon misfired explosives.

## EXPLOSIVE CHARACTERISTICS

Table 6- 3 shows the main characteristics and uses of military explosives.

Table 6-3. Military explosives characteristics

| EXPLOSIVE | USAGE | DET VEL (FPS) | RE FACTOR | SIZE, WEIGHT, AND PACKAGING |
|---|---|---|---|---|
| TNT | Breaching | 23,000 | 1.00 | 1 lb/48-56/Box; ½ lb/96-106/Box |
| Tetrytol | Breaching | 23,000 | 1.20 | 8-2½ lb/Sack; 2 Sacks/Box |
| C-4 M5A1 and M112 | Cut and Breach | 26,000 | 1.34 | M5A1: 24-2½ lb Blks/Box<br>M112: 30-1¼ lb Blks/Box |
| Sheet Exp M118<br>M186 | Cutting | 24,000 | 1.14 | 4-½ lb Sheets/Pack with 20 Packs per Box (1 Sheet 3" x ¼" x 12")<br>3-25 lb Rolls/Box (50' long) |
| Dynamite M1 | Qry/Stump/Ditch | 20,000 | 0.92 | 100-½ lb Sticks/Box |
| Det Cord | Priming | 20,000-24,000 | | 3-1,000' Rolls or 8-500' Rolls/Box |
| Crater Charge | Craters | 8,900 | 0.42 | 1-40 lb Cannister/Box |
| Bangalore M1A2 | Wire and Breaching | 25,600 | 1.17 | 10-5' Sections/Box (176 lb) |
| Shaped Charges<br>M2A4<br>M3A1 | Cutting<br>Holes | <br>25,600<br>25,600 | <br>1.17<br>1.17 | <br>4-15 lb Shaped Charges/Box<br>1-40 lb Shaped Charge/Box |

NOTES: 1. Dynamite which is to be submerged under water for a period exceeding 24 hours must be waterproofed by sealing in plastic or dipping in pitch.
2. The C-4 which is to be used under water must be kept in packages to prevent erosion.
3. Cratering charges will malfunction in the ammonium nitrate is exposed to moisture.
4. Fumes produced by detonating or burning explosives are dangerous.

## PRIMING EXPLOSIVES

Explosives may be primed with detonating cord (Figure 6-1), electrically or nonelectrically.

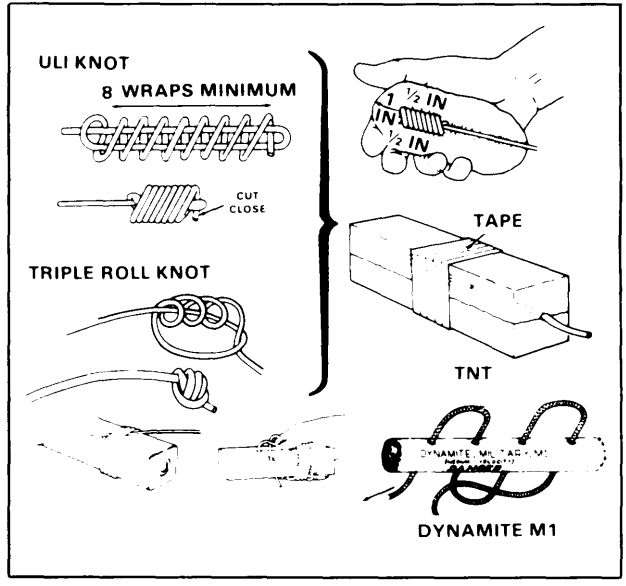



Figure 6-1. Detonating cord priming

## FIRING SYSTEMS

Firing systems may be electric or nonelectric. A dual-firing system is two completely separate systems that may be dual electric, dual nonelectric, or a combination. See Figure 6-2 for details.

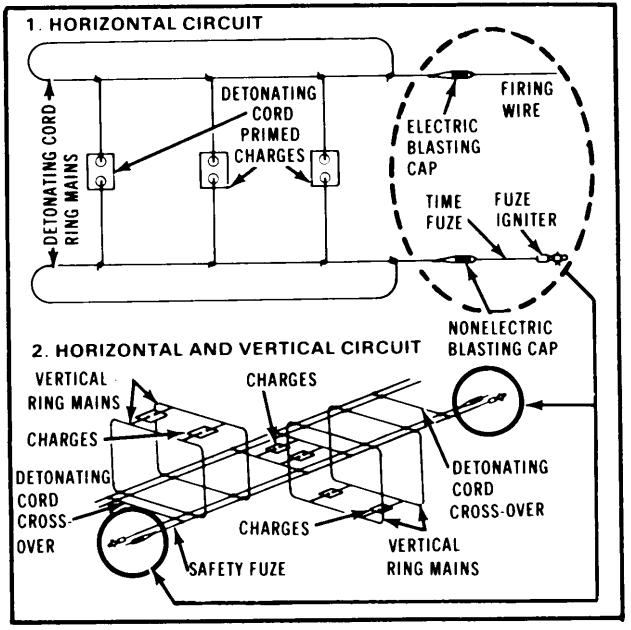



**Figure 6-2. Combination dual-firing system**

## CHARGE CALCULATIONS

General steps are shown in Figure 6-3.

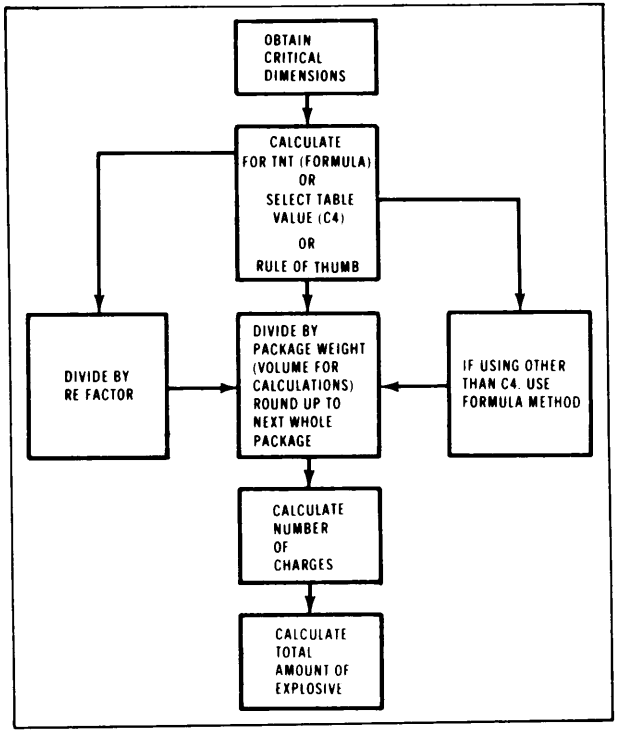



**Figure 6-3. Explosive calculation steps**

## Steel Cutting Charges

See Figure 6-4 and Table 6-4.

| FORMULA | USE |
|---|---|
| $P = \frac{1}{8} A$ | Cut beams, columns, girders, steel plates, any structural steel section, bars 2 inches thick or over. |
| $P = D^2$ | Cut high carbon or alloy steel (2 inches or less) |
| Where: | P = Pounds of TNT<br>A = Cross-section area in square inches of<br>D = Thickness or diameter in inches |

**Figure 6-4. Steel cutting formulas**

### Steel cutting rules of thumb

The required explosive is either TNT or plastic explosive (RE factor conversion is not needed.)

Rails (cut preferably at crossings switches, or curves). Cut at alternate rail splices for a distance of 500 feet.

Less than 5 inches high - use ½ pound.
Five inches or higher - use 1 pound.
Crossings and switches - use 1 pound.

**Cables, chains, rods, and bars.**

Up to 1 inch diameter use - 1 pound.
Over 1 inch to 2 inches - use 2 pounds.
Over 2 inches - use P = (1/8) A or suitable dimensional type charge.

NOTE: Chain and cable rules are for those under tension. Both sides of chain link must be cut.

**Table 6-4. C4 needed to cut steel sections**

| THICKNESS OF SECTION CM (IN) | KILOGRAMS (POUNDS) OF C4 FOR RECTANGULAR STEEL SECTIONS OF GIVEN DIMENSIONS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WIDTH OF SECTION IN CM (IN) | | | | | | | | | | | | | |
| | 5.1 (2) | 7.6 (3) | 10.2 (4) | 12.7 (5) | 15.2 (6) | 20.3 (8) | 25.4 (10) | 30.5 (12) | 35.6 (14) | 40.6 (16) | 45.7 (18) | 50.8 (20) | 55.8 (22) | 61 (24) |
| 0.6 (1/4) | .1 (.2) | .1 (.3) | .2 (.3) | .2 (.4) | .2 (.5) | .3 (.6) | .4 (.8) | .5 (.9) | .5 (1) | .6 (1.2) | .6 (1.3) | .7 (1.5) | .8 (1.6) | .8 (1.8) |
| 1.0 (3/8) | .1 (.3) | .2 (.4) | .2 (.5) | .3 (.6) | .4 (.7) | .5 (.9) | .5 (1.1) | .6 (1.3) | .7 (1.5) | .8 (1.8) | .9 (2) | 1 (2.1) | 1.1 (2.4) | 1.2 (2.6) |
| 1.3 (1/2) | .2 (.3) | .2 (.5) | .3 (.6) | .4 (.8) | .5 (.9) | .6 (1.2) | .7 (1.5) | .8 (1.8) | 1 (2.1) | 1.1 (2.3) | 1.2 (2.6) | 1.3 (2.9) | 1.5 (3.2) | 1.6 (3.4) |
| 1.6 (5/8) | .2 (.4) | .3 (.6) | .4 (.8) | .5 (.9) | .5 (1.1) | .7 (1.5) | .9 (1.8) | 1 (2.2) | 1.2 (2.5) | 1.3 (2.9) | 1.5 (3.2) | 1.6 (3.5) | 1.8 (3.9) | 2 (4.3) |
| 1.9 (3/4) | .2 (.5) | .4 (.7) | .5 (.9) | .5 (1.1) | .6 (1.3) | .8 (1.8) | 1 (2.1) | 1.2 (2.6) | 1.4 (3) | 1.6 (3.4) | 1.8 (3.8) | 2 (4.3) | 2.2 (4.7) | 2.4 (5.1) |
| 2.2 (7/8) | .3 (.6) | .4 (.8) | .5 (1.1) | .6 (1.3) | .7 (1.5) | 1 (2.1) | 1.2 (2.5) | 1.4 (3) | 1.6 (3.5) | 1.8 (4) | 2.1 (4.5) | 2.3 (5) | 2.5 (5.5) | 2.7 (5.9) |
| 2.5 (1) | .3 (.6) | .5 (.9) | .6 (1.2) | .7 (1.5) | .8 (1.8) | 1.1 (2.3) | 1.3 (2.9) | 1.6 (3.4) | 1.8 (4) | 2.1 (4.5) | 2.4 (5.1) | 2.6 (5.6) | 2.9 (6.2) | 3.1 (6.8) |

NOTE Rounded up to next 1/10 pound and kilogram

Use table to:
1. Measure rectangular sections of member separately
2. Find charge for each section
3. Add charges for sections to find total charge
4. If dimension is not on table, use next larger dimension

## Emplacement of charge and sample problem

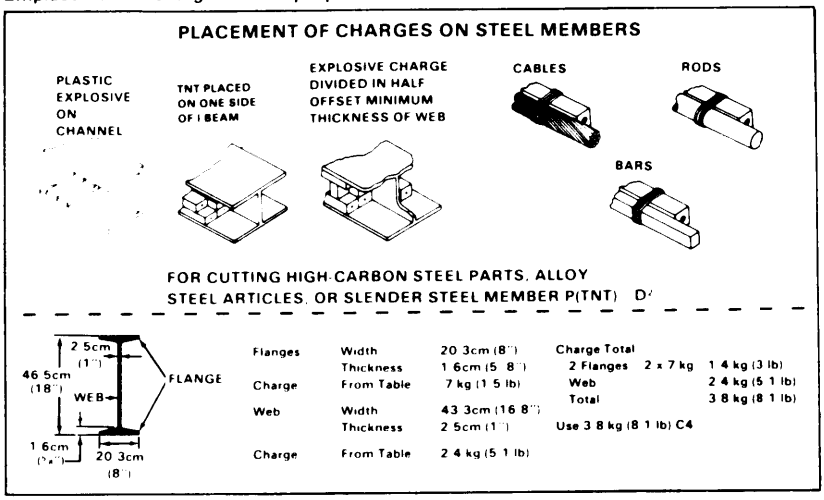



Figure 6-5. Steel cutting charges emplacement

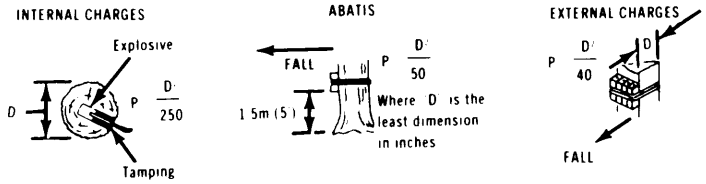
## Special steel cutting charges

| CHARGE TYPE | USE AND DIMENSIONS | REMARKS |
|---|---|---|
| BEAMS LESS THAN 2 INCHES THICK: Offset flange charge so that one edge is opposite center of C-shaped charges<br>Ribbon<br>BEAMS 2 INCHES THICK OR MORE: Offset flange charge so that one edge is opposite an edge of the C-shaped charges<br>PRIMING: Detonating cord primers must be of equal length | Cut flat steel up to 3" thick (Plates, beams, columns)<br>Depth ½ thickness of target<br>Width 3 times thickness of charge<br>Length Same as length of cut desired | - ½" minimum charge thickness<br>- Cut explosive. DO NOT mold<br>Explosive target contact must exist over entire area |
| DETONATION AT APEX<br>BASE ½ CIRCUMFERENCE<br>Saddle<br>LONG AXIS CIRCUMFERENCE<br>THICKNESS 1" | Cut solid bars up to 8" thick<br>See diagram for charge dimensions | - Explosive must be cut rather than molded<br>- Difficult |
| SHORT AXIS ½ CIRCUMFERENCE AND POINTS OF DETONATION<br>Diamond<br>1" THICK<br>LONG AXIS CIRCUMFERENCE | Cut solid bars up to 8" thick<br>See diagram for charge dimensions | Detonating cord primers at apexes must be equal length |

Figure 6-6. Special steel cutting charges

## Timber Cutting Charges

Figure 6- 7 shows charge placement formulas and amount of explosive. Whenever possible, a test shot should reconducted to determine the exact amount of explosive required to obtain the desired effect. Use the values or formulas given in Figure 6-7 for initial test shot. After the initial result, increase or decrease the amount of explosive as appropriate. See Figure 6-8 for stumping operations. Use ring charges as shown in Figure 6-7 when full removal is not desired.




| TYPE OF CHARGE | EXPLOSIVE | LEAST DIMENSION OF TIMBER IN CM (IN) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15.2 (6) | 20.3 (8) | 25.4 (10) | 30.5 (12) | 38.1 (15) | 45.7 (18) | 53.3 (21) | 61 (24) | 68.6 (27) | 76.2 (30) | 83.8 (33) | 91.4 (36) |
| | | EXPLOSIVE IN KG (LB) | | | | | | | | | | | |
| INTERNAL | C4 | .3 (.5) | .3 (.5) | .3 (.5) | .3 (.5) | .5 (1) | .5 (1) | .7 (1.5) | .9 (2) | 1.1 (2.5) | 1.4 (3) | 1.6 (3.5) | 1.8 (4) |
| EXTERNAL | C4 | .5 (1) | .7 (1.5) | .9 (2) | 1.4 (3) | 2 (4.5) | 3 (6.5) | 3.9 (8.5) | 5 (11) | 6.4 (14) | 7.8 (17) | 9.4 (20.5) | 11.2 (24.5) |
| ABATIS | C4 | .5 (1) | .7 (1.5) | .7 (1.5) | 1.1 (2.5) | 1.6 (3.5) | 2.3 (5) | 3.2 (7) | 4.1 (9) | 5 (11) | 6.2 (13.5) | 7.5 (16.5) | 8.9 (19.5) |

NOTES 1. Explosive is rounded up to next 1/2 lb or 1/10 Kg.
2. For external timber cutting, the charge should be twice as wide as it is high.
3. The depth of borehole for internal charges should be 2D/3 and two boreholes should be used for trees over 18 inches in diameter. Borehole diameter should be 2 inches to allow for explosive packing.

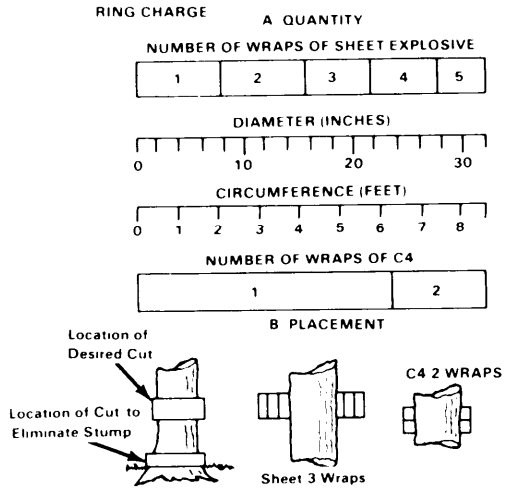



**Figure 6-7 Timber cutting charges**

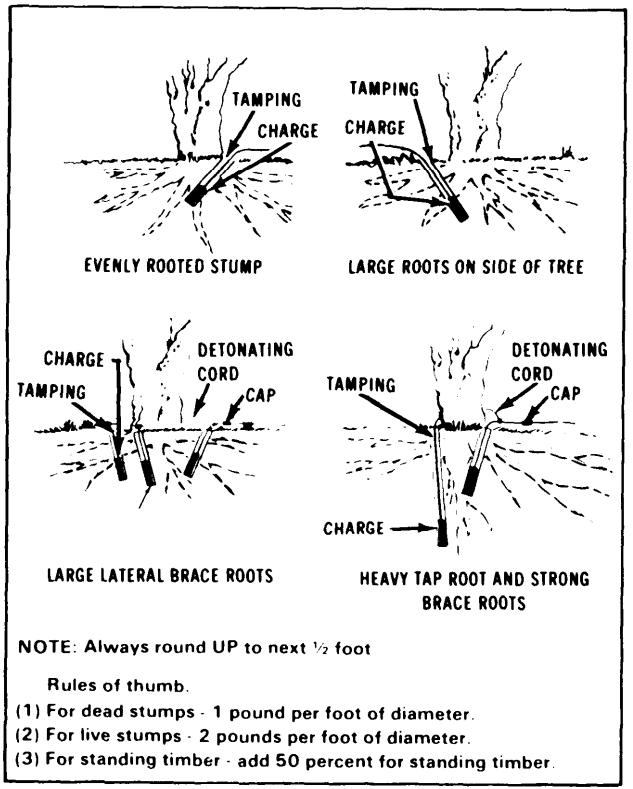



Figure 6-8. Stump blasting methods for various root structures

**Breaching Charges**

Table 6-5 shows quantity of explosive for reinforced concrete. Quantity for other materials may be obtained by use of a conversion factor (Table 6-5 page 6-8)

Breaching formulas: $P = R^3KC$

Where P = pounds of TNT
R = breaching radius (Figure 6-9)
K = material factor (Table 6-6)
C = tamping factor (Table 6-5)

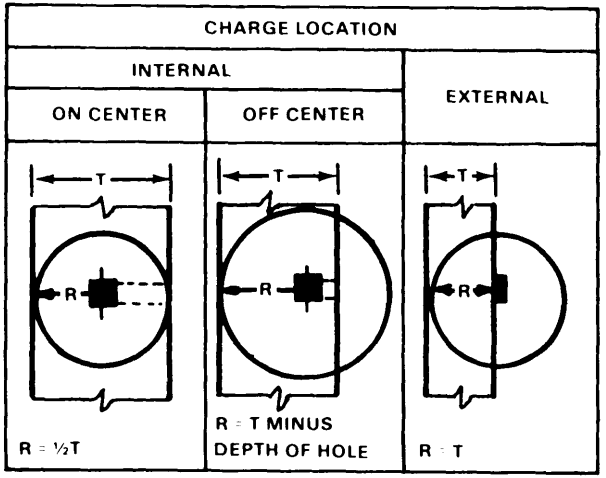



Figure 6-9. Breaching radius

**Table 6-6. Values of K (material factor) for breaching charges**

| MATERIAL | R M (FT) | K |
|---|---|---|
| Earth | All values | 0.07 |
| Poor masonry, shale, hardpan, good timber, and earth construction | Less than 1.5 (5) | 0.32 |
| | 1.5 (5) or more | 0.29 |
| Good masonry, concrete block, rock | .3 (1) or less | 0.88 |
| | over .3 (1) to less than .9 (3) | 0.48 |
| | .9 (3) to less than 1.5 (5) | 0.40 |
| | 1.5 (5) to less than 2.1 (7) | 0.32 |
| | 2.1 (7) or more | 0.27 |
| Dense concrete, first-class masonry | .3 (1) or less | 1.14 |
| | over .3 (1) to less than .9 (3) | 0.62 |
| | .9 (3) to less than 1.5 (5) | 0.52 |
| | 1.5 (5) to less than 2.1 (7) | 0.41 |
| | 2.1 (7) or more | 0.35 |
| Reinforced concrete (concrete only, will not cut reinforcing steel) | .3 (1) or less | 1.76 |
| | over .3 (1) to less than .9 (3) | 0.96 |
| | .9 (3) to less than 1.5 (5) | 0.80 |
| | 1.5 (5) to less than 2.1 (7) | 0.63 |
| | 2.1 (7) or more | 0.54 |

Number of charges and thickness (Table 6-7

Formula:

$$N = \frac{W}{2R}$$

Where N = number of charges
W = width
R = breaching radius (feet)

Round off rule for N

Less than 1.25 - use 1 charge
1.25 to 2.49 - use 2 charges
2.5 or greater - round off to nearest whole number

**Table 6-7. Thickness of breaching charge**

| AMOUNT OF EXPLOSIVE | THICKNESS OF CHARGE |
|---|---|
| Less than 5 lb | 1 in |
| 5 lb to less than 40 lb | 2 in |
| 40 lb to less than 300 lb | 4 in |
| 300 lb or more | 8 in |

Thickness of breaching charge is in approximate values.

For best result, place charge in a flat square shape with flat side to target. For breaching of hard surface pavements use 1 pound of explosive for each 2 inches of surface.

## Table 6-5. Breaching charge calculation

C4 BREACHING CHARGES REINFORCED CONCRETE ONLY

| THICKNESS OF CONCRETE | METHODS OF PLACEMENT | | | | |
|---|---|---|---|---|---|
| | | | | | |
| C FACTOR | 1.0 | 1.0 1.0 | 1.8 | 2.0 2.0 | 3.6 |
| EXPLOSIVE | C4 | C4 | C4 | C4 | C4 |
| M (FT) | Kg (LB) | Kg (LB) | Kg (LB) | Kg (LB) | Kg (LB) |
| 0.6 (2) | .7 (1.5) | 2.8 (6) | 4.8 (10.5) | 5.5 (12) | 9.6 (21) |
| 0.8 (2.5) | 7 (1.5) | 5.3 (11.5) | 9.4 (20.5) | 10.3 (22.5) | 18.5 (40.5) |
| 0.9 (3) | 1.4 (3) | 7.5 (16.5) | 13.5 (29.5) | 15 (33) | 26.6 (58.5) |
| 1.1 (3.5) | 2.1 (4.5) | 12.1 (26.5) | 21.2 (46.5) | 23.5 (51.5) | 42.3 (93) |
| 1.2 (4) | 2.8 (6) | 17.8 (39) | 31.6 (69.5) | 35.0 (77) | 63 (138.5) |
| 1.4 (4.5) | 3.9 (8.5) | 24.8 (54.5) | 44.8 (98.5) | 49.6 (109) | 89.4 (196.5) |
| 1.5 (5) | 5.3 (11.5) | 26.9 (59) | 48.2 (106) | 53.7 (118) | 96.4 (212) |
| 1.7 (5.5) | 6.9 (15) | 35.7 (78.5) | 64.4 (141.5) | 71.4 (157) | 128.7 (283) |
| 1.8 (6) | 7.5 (16.5) | 46.2 (101.5) | 83.2 (183) | 92.8 (204) | 166.4 (366) |
| 2.0 (6.5) | 9.6 (21) | 58.9 (129.5) | 106 (233) | 117.5 (258.5) | 211.4 (465) |
| 2.1 (7) | 12.1 (26.5) | 63.2 (139) | 113.5 (249.5) | 126 (277) | 226.4 (498) |
| 2.3 (7.5) | 14.8 (32.5) | 77.5 (170.5) | 139.1 (306) | 154.8 (340.5) | 278.1 (613) |
| 2.4 (8) | 17.8 (39) | 94.1 (207) | 169.1 (372) | 187.8 (413) | 338 (743.5) |

NOTE Rounded up to the next 1/2 pound. 1/10 Kg

CONVERSION FACTOR FOR TABLE
(K FACTOR. USE WITH TABLE)

| EARTH | ORDINARY MASONRY. HARDPAN. SHALE. ORDINARY CONCRETE. ROCK. GOOD TIMBER. AND EARTH CONSTRUCTION | DENSE CONCRETE FIRST CLASS MASONRY |
|---|---|---|
| 0.1 | 0.5 | 0.7 |

To use tables in calculating breaching charges

1. Determine the type of material in the object you plan to destroy. If in doubt, assume the material to be of the stronger type. such as. unless you know differently. assume concrete to be reinforced.
2. Measure thickness of object.
3. Decide how you will place the charge against the object. Compare your method of placement with the diagrams at the top. If there is any question as to which column to use. always use the column that will give you the greater amount of C4.
4. Use the table to determine the amount of C4 that would be required if the object were made of reinforced concrete.
5. Determine the appropriate conversion factor.
6. Multiply the number of pounds of C4 (from table) by the conversion factor.

Example

A timber earth wall 2m (6.5 ft) thick and an explosive charge placed at the base of the wall without tamping. If this wall was made of reinforced concrete. 211.4 Kg (465 lb) of C4 would be required to breach it. The conversion factor is 0.5. Multiply 211.4 Kg (465 lb) of C4 by .05 and the result is 115.7 Kg (235.2 lb) of C4 required to breach the wall.

## Counterforce Charges

Counterforce charges are pairs of opposing charges to fracture small concrete or masonry blocks and columns. It is not effective against a thickness over 4 feet (Figure 6 -10).

Calculations: P = 1.5 x T
P = pounds of plastic explosive
T = thickness in feet (round UP to next ½ foot)

Example: Column 3 feet x 3 feet
P = 1.5 x 3 = 4.5 pounds

Divide by package weight and round UP to next package. Then divide charge into two equal parts. Place charges opposite to each other and detonate simultaneously.

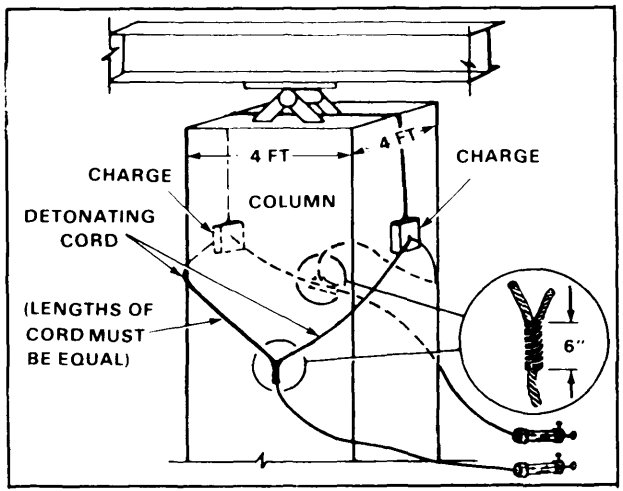
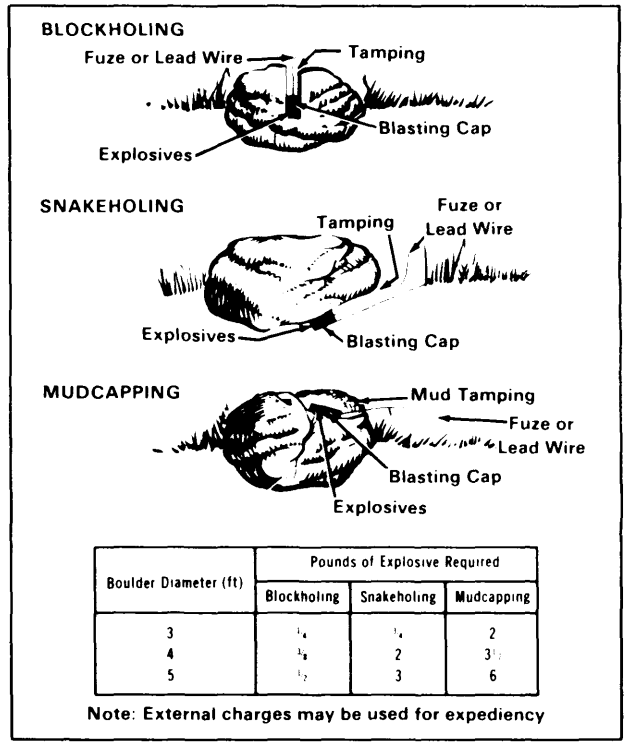



Figure 6-10. Counterforce charge

## Boulder Blasting Charges




| Boulder Diameter (ft) | Pounds of Explosive Required | | |
|---|---|---|---|
| | Blockholing | Snakeholing | Mudcapping |
| 3 | [illegible] | [illegible] | 2 |
| 4 | [illegible] | 2 | 3[illegible] |
| 5 | [illegible] | 3 | 6 |

Note: External charges may be used for expediency

Figure 6-11. Boulder blasting

## Cratering Charges

The three types of road craters are hasty, deliberate, and relieved face (figure 6-12 through 6-14). Road craters are usually emplaced by digging the holes by hand mechanically or with 15 or 40 pound shaped charges. These holes are then loaded with the required amount of explosive. (Place C4 on top of cratering charges.)

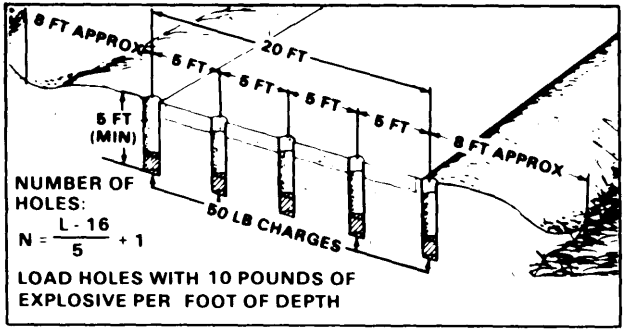



Figure 6-12. Hasty road crater

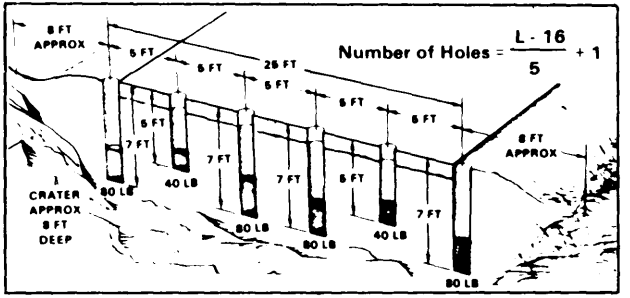



Figure 6-13. Deliberate road crater

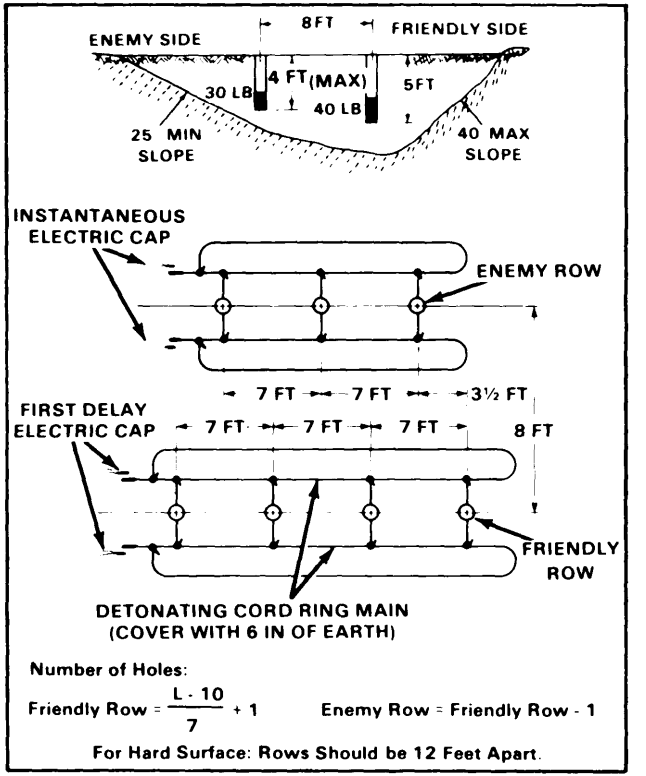



Figure 6-14. Relieved face road crater

Another method of road cratering is by using the M180 demolition cratering kit. The M180 kit consists of a shaped and a cratering charge configured to detonate as a single charge. Figure 6-15 shows the M180 configuration for road cratering. The M180 is only good for soft unfrozen soils and nonreinforced concrete. Test shots are advised.

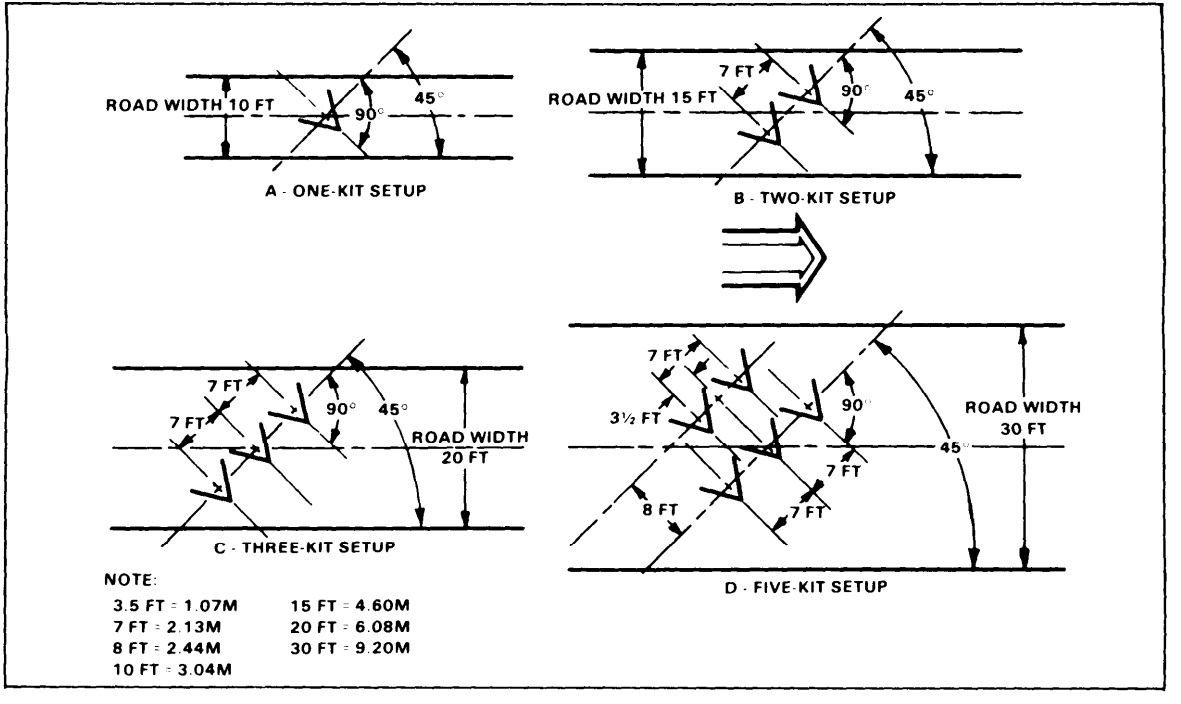



**Figure 6-15. Deployment steps of M180**

## BRIDGE DEMOLITIONS

When bridge demolition is used to create an obstacle, the bridge should be demolished to permit the most economical reconstruction by friendly troops and make its use difficult or impossible for the enemy. Bridge demolition consideration factors are-

Ž Type of spans/supports
• Anticipated result of cutting spans at different points
• Critical span.
Ž Desired extent of destruction and repair.
Ž Difficulty and accessibility of desired point of cut by friendly versus enemy forces.
• Identification and measurement of each member in the plane of cut.

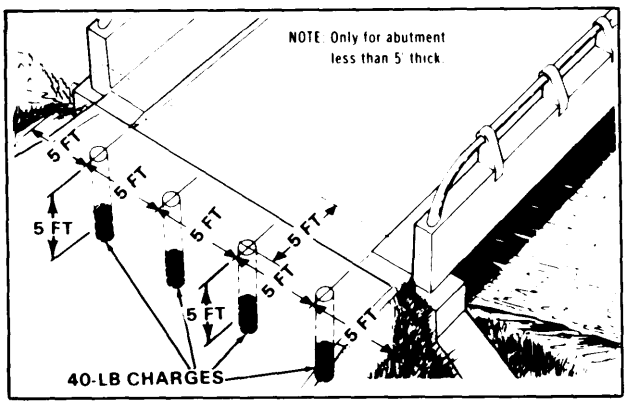



**Figure 6-16. Placement of the 5-5-5-40 charge (triple-nickel-forty)**

### Abutment and Pier Demolitions

See Figures 6-16 through 6-18. Single abutment destruction should be on the friendly side.

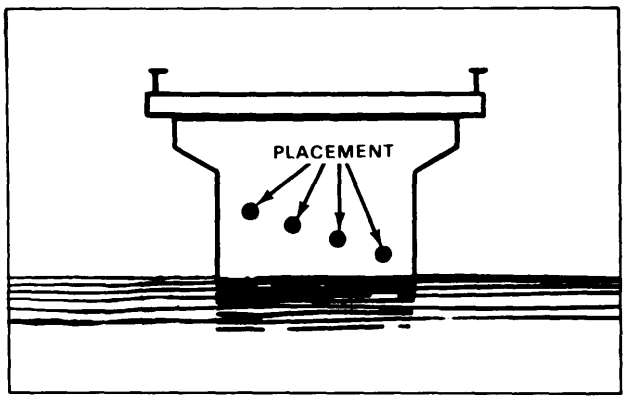



**Figure 6-17. Pier demolition**

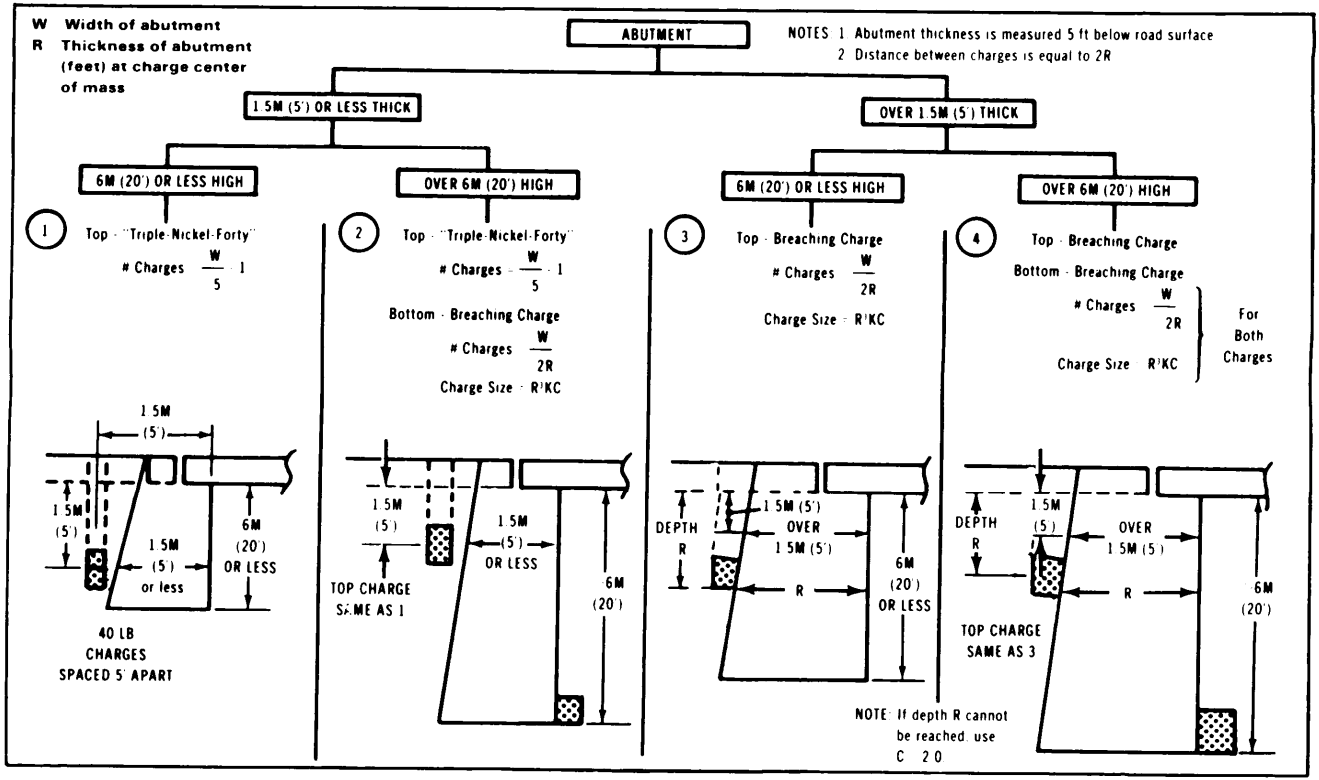



Figure 6-18. Bridge abutment demolition

## Bridge Span Demolition

Figure 6-19 shows different span types and their respective plane of cut. Timber spans may be destroyed using formulas and calculations for regular timber. Figures 6-20 through 6-23 show how to destroy spans designed of steel or concrete. If total demolition is not specified in figure calculate the amount required using the appropriate table or formula.

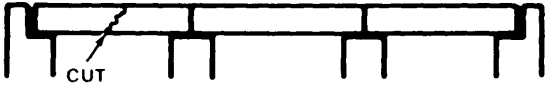
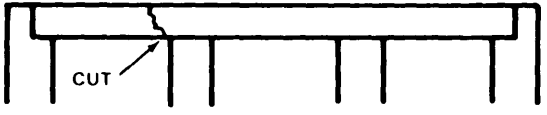
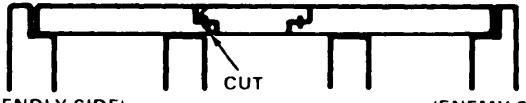
| TYPE | DIAGRAM | REMARKS |
|---|---|---|
| Simple |  | - May be single or multiple<br>In multiple, mid-span is the most critical<br>- In shallow gaps, use multiple cuts |
| Continuous |  | - To drop more than one span cut at the ¾ point of desired spans to drop from friendly support |
| Cantilever |  <br>(FRIENDLY SIDE) (ENEMY SIDE) | May not have suspended span<br>- Suspended may be pin connected<br>- Cut as not to leave a balanced section |

Figure 6-19. Span type and location to drop one span

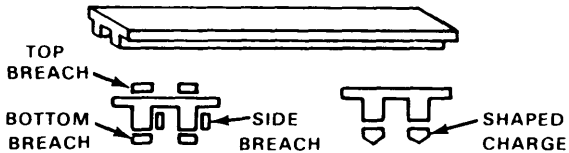
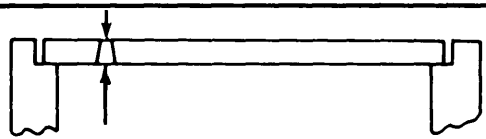
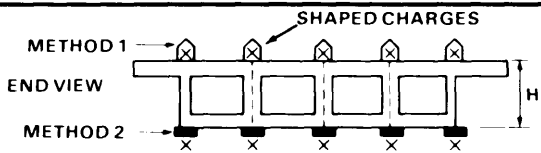
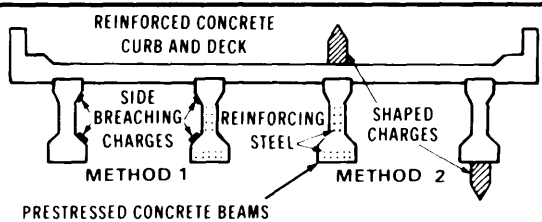
| TYPE | DIAGRAM AND CHARGE EMPLACEMENT | REMARKS |
|---|---|---|
| Concrete T-Beam |  | Use either method shown in diagram. |
| Concrete Slab |  | Use breacing charges. Breach top or bottom. |
| Concrete Box Beam |  | Use external breaching charges (Method 2) or shaped charges (Method 1). |
| Concrete I-Beam |  | Use either method. Method 2 is preferred. Detonate charges simultaneously. If beam is 1 meter or less, use 3 lb on bottom flange and 2 lb on top flange. |

Figure 6-20. Concrete beam span destruction

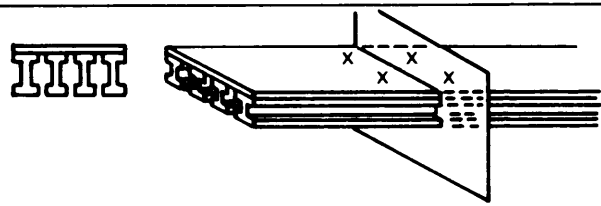
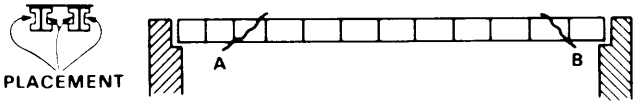
| TYPE | DIAGRAM AND CHARGE EMPLACEMENT | REMARKS |
|---|---|---|
| Steel Stringer |  | Charges should be staggered to cut stringers at different lengths. |
| Steel Plate Girder |  | Method 1: Totally cut one girder at both ends.<br>Method 2: For total distruction, cut both girders at both ends. |

Figure 6-21. Steel stringer and girder span destruction

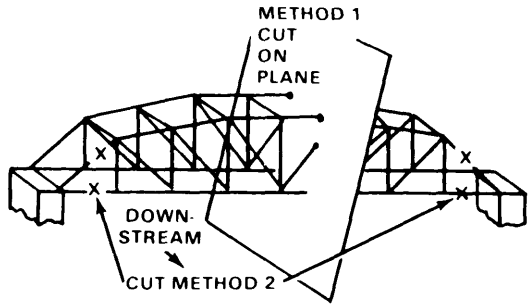
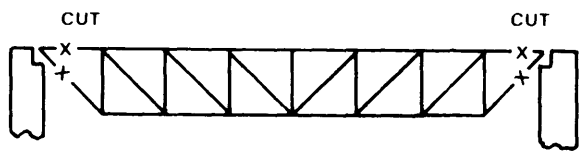
| TYPE | DIAGRAM AND CHARGE EMPLACEMENT | REMARKS |
|---|---|---|
| Through Truss |  | On Method 1, cut all members on plane.<br><br>On Method 2, four other charges placed upstream will drop the entire bridge. |
| Deck Truss |  | See remarks above. |

Figure 6-22. Steel truss span destruction

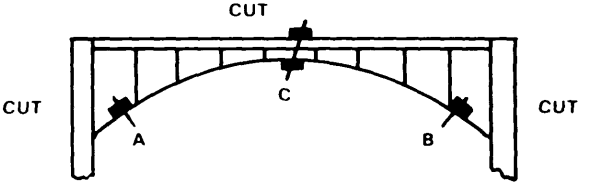
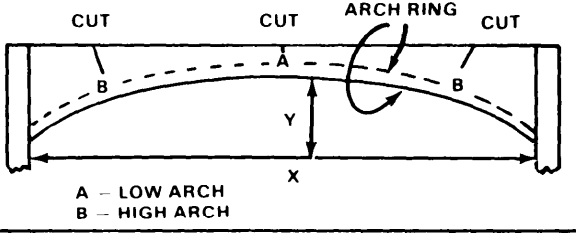
| TYPE | DIAGRAM AND CHARGE EMPLACEMENT | REMARKS |
|---|---|---|
| Open Spandrel Arch |  | Must be cut at A, B, and C. |
| Filled Arch Bridge |  | Charges must be placed at the arch ring. Destroy capstone (keystone) |

Figure 6-23. Arch span destruction

## Demolition Reconnaissance

Figure 6-24 shows the DA Form 2203 R(Demolition Reconnaissance Report) and its use. For reconnaissance procedures, see Chapter 5.

| Item No | Information Required |
|---|---|
| 8 | What and where it is (town vicinity of) |
| 11 | Sketch must show relative position of objects to be demolished, terrain features, safe distances, routes, and avenues of approach. Location of features of the site. One sketch must show fully dimensioned plan views, and cross-sections of object and of each memeber to be cut. (This may be listed under 12.) |
| 12 | Show plan and cross-sectional sketch of each member to be cut. Show details of chambers, line of cut, and location of charges. Show quantity of explosive per charge and metod of ignition. Sketch must show firing circuits and firing points. |
| 13 | Describe each in detail and show location on situation map sketch. |

**DEMOLITION RECONNAISSANCE REPORT**

For use of this form see FM 5-25; the proponent agency is TRADOC

**SECTION I GENERAL**

| 1 FILE NO | 2 DML RECON REPORT NO | 3 DATE | 4 TIME |
|---|---|---|---|
| 001 | 3-AD-7-P | 18 MAY 86 | 0700 |

| | NAME | GRADE | ORGANIZATION |
|---|---|---|---|
| 5 RECON ORDERED BY | JOHN DOE | 03 | A Co 23rd ENGR. BN. |
| 6 PARTY LEADER | JOE SMITH | 01 | A Co 23rd ENGR. BN. |

| 7 MAP NAME | SCALE | SHEET NO | SERIES NO |
|---|---|---|---|
| INDIAN HEAD | 1:50,000 | 5561 II | V733 |

| 8 TARGET AND LOCATION | 9 TIME OBSERVED | 10 COORDINATES |
|---|---|---|
| RAILROAD BRIDGE, 15 MILES EAST OF WARREN | 0900 | PD23174891 |

11 GENERAL DESCRIPTION (attach sketches) 3 SIMPLE SPANS, (TWO PLATE GIRDER & ONE DECK TRUSS) INTERMEDIATE SUPPORT CONCRETE, ABUTMENTS EARTH AND WOOD CONSTRUCTION (SKETCH ALL CRITICAL DEMENSIONS)

12 NATURE OF PROPOSED DEMOLITION (attach sketches) ONE ABUTMENT AND ONE INTERMEDIATE SUPPORT (SKETCH A CROSS-SECTIONAL SKETCH AND SHOW PLACEMENT OF CHARGES AND IGNITION SYSTEM)

13 UNUSUAL FEATURES OF SITE POWER LINES, WATER 30' DEEP (SKETCH ON SITUATION MAP SKETCH)

**SECTION II ESTIMATES***

| 14 EXPLOSIVES REQUIRED A TYPES | B QUANTITY | C CAPS ELECTRIC | C CAPS NONELECTRIC | D DETONATING CORD | E TIME FUSE | F FUSE LIGHTERS | G FIRING WIRE |
|---|---|---|---|---|---|---|---|
| M112 | 50 PKGS | | | 1000' | | 2 EA. | |
| M118 | 20 PKGS | | | | | | |
| Cratering Charge | — 4 EA. | | | | | | |
| Shape Charge | — 4 EA. | | 20 EA | | 50' | | |

15 EQUIPMENT AND TRANSPORT REQUIRED
1-SQUAD DEMO SET
10-1"x6"x12' PINEBOARD
2-3 TON DUMPS W/TRAILERS
2-ROLLS DUCT TAPE
2-POSTHOLE DIGGERS

| 16 PERSONNEL AND TIME REQUIRED FOR | NCO's | MEN | TIME |
|---|---|---|---|
| A PREPARING AND PLACING THE CHARGES | 2 | 8 | 2 Hrs. |
| B ARMING AND FIRING THE DEMOLITION | 1 | 2 | 2 Min. |

17 TIME LABOR AND EQUIPMENT REQUIRED FOR BYPASS SPECIFY LOCATION AND METHOD 100 Ft. MGB
1-ENGR. PLT. BY PASS 3 MILES SOUTH (Rt. 142)

* DETERMINE AVAILABILITY OF ITEMS 14, 15 AND 16 BEFORE RECONNAISSANCE

DA Form 2203-R, Aug 70

**Figure 6-24. Demolition reconnaissance report**

## EXPEDIENT DEMOLITIONS

### Improvised Cratering and Shaped Charges

**Cratering charge**

To make a cratering charge use a mixture of dry fertilizer (at least 33 1/3 percent nitrogen, see package contents list) and liquid (diesel fuel motor oil, or gasoline) at a ration of 25 pounds of fertilizer to a quart of liquid. Mix fertilizer with liquid and allow to soak for an hour. Place half of the charge weight in hole, place 1 pound of primed explosive, and then pour in other half of the charge.

**Shaped charge**

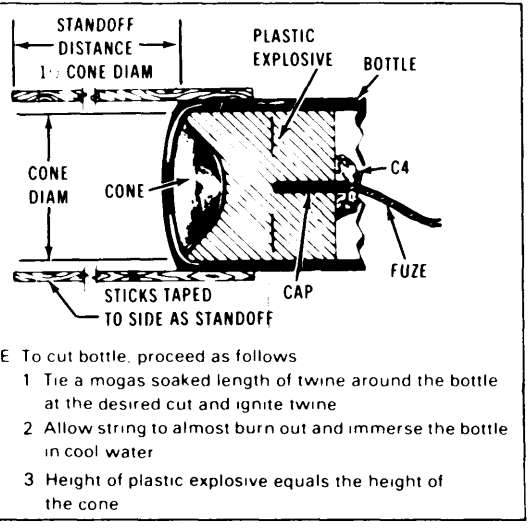



**Figure 6-25. Improvised shaped charge**

### Satchel Charge

Melt ordinary paraffin (wax) and stir in ammonium nitrate (fertilizer) pellets. Make sure that the paraffin is hot while mixing. Before the mixture hardens add a half pound block of TNT or its equivalent as a primer. Pour the mixture into a container. Shrapnel material may be added to the mixture if desired or attached on the outside of the container to give a shrapnel effect.

### Improvised Bangalore Torpedo

The principal use of an improvised bangalore torpedo is to clear paths through barbed wire entanglements using one of the three methods.

**Method one**

Use any length of pipe with approximately a 2-inch inside diameter and a wall thickness of at least .025 inch (24-gage). Pack the pipe with 2 pounds of explosive per foot of length. Close one end of the pipe with threaded cap, wooden plug, or damp earth.

**Method two**

Use any length of a U-shaped picket. Pack the inside section of the U-shaped picket with 2 pounds of explosives per foot of length. Place the steel section of the U shaped picket up.

**Method three**

Use any length of board. Attach 4 pounds of explosive per foot of length. Place explosives up.

### Detonating Cord Wick

Use a detonating cord wlck to widen bore holes. One strand will generally widen the hole 1 inch. Tape together the desired number of strands and prime one stick of dynamite with one of the strands. (The dynamite is used to clean the hole.) Place wick and dynamite in hole. The wick must extend from the bottom of the hole to the surface. Prime wick and detonate. Ensure hole is cold before putting in any other explosives.

### Expedient Time Fuze

Soak length of clean string (⅛-inch diameter) in gasoline and hang to dry. After drying, store in a tightly sealed container. Handle as little as possible and test extensively before use.

Chapter 7

Bridging

## RIVER CROSSING

### Operations

River crossing operations may be hasty, deliberate, or retrograde. Deliberate crossings are always conducted in three phases: assault, rafting (Table 7-1), and bridging.

**Table 7-1. Planning factors for rafting operations**

| RIVER WIDTH M (FT) | MINUTES PER ROUND TRIP | MAXIMUM NUMBER OF RAFTS PER CENTERLINE |
|---|---|---|
| 75 (246) | 7 | 1 |
| 100 (328) | 8 | 1 |
| 125 (410) | 9 | 1 |
| 150 (492) | 10 | 2 |
| 225 (738) | 12 | 2 |
| 300 (984) | 16 | 3-5 |
| 450 (1.476) | 22 | 5-7 |

NOTES: 1. This table provides apprximate crossing times for LTR, Ribbon, M4T6. and Class 60 rafts in currents of 0.5MPS (0-1.5 FPS).

2. All round trip times include the time required to load and unload the rafts.
3. Increase crossing times by 50 percent at night.
4. Interpolate crossing times as necessary.



[redacted]

Table 7-2. Assault crossing equipment

| EQUIPMENT | ALLOCATION | TRANSPORTATION | CAPABILITIES | ASSY/PROPULSION | REMARKS/LIMITATIONS |
|---|---|---|---|---|---|
| Pneumatic 15-man assault boat | J series TOE provides:<br>• 18/Div Eng Bn<br>• 27/Corps Float Bridge Co<br>• 9/Sep Bde Eng Co | • 20 deflated boats per 2½-ton truck<br>• Inflated boat is an 8-man carry<br>• Deflated boat weighs 250 lb. | Carries:<br>• 12 Inf and 3 Eng w/paddles<br>or<br>• 12 Inf and 2 Eng w/OBM<br>or<br>• 3,375 lb of equipment | • Inflation time is 5-10 minutes with pumps<br>• Paddled speed is 1.5MPS (5 FPS)<br>• Speed with OBM is 4.6MPS (15 FPS) | • Max current velocity:<br>w/paddle - 1.5MPS (5 FPS)<br>w/OBM - 3.5MPS (11 FPS)<br>• 3 pumps, 11 paddles per boat<br>• OBMs must be requested separately |
| Pneumatic 3-man reconnaissance boat | J series TOE provides:<br>• 3/Cbt Eng Co<br>• 10 Corps Float Bridge Co (L Series)<br>• 18/Div Ribbon Co | • Carried by back-pack (1-man carry)<br>• Boat and backpack weigh 37 lb | Carries:<br>• 3 soldiers with equipment<br>or<br>• 600 lb of equipment | • Inflation time is 5 minutes with a pump<br>• Paddle speed is 1.0MPS (3 FPS) | • Max current velocity 1.5MPS (5 FPS)<br>• 1 pump, 3 paddles per boat<br>• No provisions for OBMs |
| Armored personnel carrier (APC) | J series TOE provides:<br>• 12/Eng Co of Div Eng Bn<br>• 1/Inf Co (Mech) (BIFV)<br>• 14/Inf Co (Mech) (M113) | • Self-propelled<br>• Class 13 vehicle | Carries:<br>• 12 soldiers with equipment | • Preparation time for swimming is 10 minutes<br>• Track propulsion in the water<br>• Swim speed is 1.6MPS (5.3 FPS)<br>• Can ford up to 1.5M (5 ft) | • Max current velocity: 1.5MPS (5 FPS)<br>• Drift (M) = $\frac{\text{Current (MPS)}}{1.6}$ x river width (M)<br>• Drift (ft) = $\frac{\text{Current (FPS)}}{5.3}$ x river width (ft) |

Table 7-2. Assault crossing equipment (continued)

| EQUIPMENT | ALLOCATION | TRANSPORTATION | CAPABILITIES | ASSY/PROPULSION | REMARKS/LIMITATIONS |
|---|---|---|---|---|---|
| Bradley infantry fighting vehicle (BIFV) | J series TOE provides:<br>• 13/Inf Co (Mech) (BIFV)<br>• 12/Cav Troop of an ACR<br>• 19/Cav Troop of an Div Cav Sqdn | • Self-propelled<br>• Class 25 vehicle | Carries<br>• 10 soldiers with equipment | • Preparation time for swimming is 18 minutes | • Max current velocity: 0.9MPS (3 FPS)<br>• Drift (M): $\frac{\text{Current (MPS)}}{2}$ x river width (M)<br>• Drift (ft): $\frac{\text{Current (FPS)}}{6.6}$ x river width (ft) |
| Armored vehicle launched bridge (AVLB) | Engr Bn of Heavy Div:<br>• 16 launchers<br>• 16 bridges<br>Engr Co of Arm/Inf (M) Sep Bde:<br>• 3 launchers<br>• 3 bridges | Bridge carried on launcher (modified) M48A5 or M60A1 chassis)<br>Bridge weighs 15T<br>20T crane transfers to launcher in 20-30 minutes | Class 60 vehicle<br>One vehicle crossing at a time<br>AVLB (19.2M-63 ft) spans:<br>• 18.3M (60 ft) using prepared abutments<br>or<br>• 17M (57 ft) using unprepared abutments | Launched in 2-5 min by buttoned-up 2-man crew<br>Retrieved from either end; one soldier exposed; guide and connect<br>Allow 9.0M (3 ft) bearing for an unprepared abutment; 0.5M (1.5 ft) for a prepared abutment | M48A2 requires gas while M60 and M48A5 are diesel<br>Scissors launch requires 10M (32.8 ft) overhead clearance<br>Max launch slope<br>• Uphill 2.7M (9 ft)<br>• Downhill 2.7M (9 ft)<br>• Sideslope 0.3M (1 ft)<br>AVLB fords 1.2M (4 ft) |

## Bridging/Rafting

**Boats.** The current standard is the Bridge Erection Boat Shallow Draft (BEB-SD). Also still in use is the older 27-foot Bridge Erection Boat (BEB). Refer to TM 5-210 for additional information.

**Table 7-3. Bridge erection boats**

| EQUIPMENT | ALLOCATION | TRANSPORTATION | CAPABILITIES | ASSY/PROPULSION | REMARKS/LIMITATIONS |
|---|---|---|---|---|---|
| Bridge erection boat - shallow draft (BEB-SD) | J series TOE provides:<br>• 12/Div Ribbon Company<br>• 14/Corps Ribbon Company<br>• 10 Corps Float Bridge Company (M4T6) | Carried by:<br>• One 5-ton bridge truck w/ cradle<br>or<br>• One medium lift helicopter<br>Boat weighs 8,800 lb | Carries a 3-man crew and:<br>• 12 soldiers with equipment<br>or<br>• 4,400 lb of equipment | • Launch time from the cradle is 5 minutes<br>• Maximum speed is 25 knots | Draft<br>• For normal operation— 22 in<br>• When fully loaded— 26 in<br>• For launch from the cradle—48 in |
| 27-foot bridge erection boat (BEB) | Same as above<br>Note: Units will normally have either the BEB-SD or the 27-ft BEB | Carried by:<br>• One 5-ton bridge truck w/cradle<br>or<br>• One 2½-ton truck w/pole trailer<br>or<br>• One medium lift helicopter when procedures are certified | Carries a 3-man crew and:<br>• 9 soldiers with equipment<br>or<br>• 3,000 lb of equipment | • Launch time from the cradle is 5 minutes<br>• Launch time from the 2½-ton truck when using a crane or wrecker is 30 minutes<br>• Maximum speed is 15 knots | Draft is 40 in |

**Improved Float Bridge (Ribbon).** The Ribbon major components are the interior bay which weighs 12,000 pounds (5,443 kilograms) and the ramp bay which weighs 11,700 pounds (5,307 kilograms). Refer to TM 5-5420-209-12 for additional information.

*Allocation.*

**Table 7-4. Allocation of Ribbon bridge (J series TOE)**

| | DIVISIONAL RIBBON COMPANY | CORPS RIBBON COMPANY |
|---|---|---|
| Number of bridge platoons | 2 | 2 |
| Number of interior bays | 20 | 30 |
| Number of ramp bays | 8 | 12 |
| Number of bridge erection boats | 12 | 14 |
| Longest bridge that can be constructed M (ft) | 148 (485) | 215 (705) |

*Methods of launch from the 5-ton bridge truck.*

**Table 7-5. Launch restrictions**

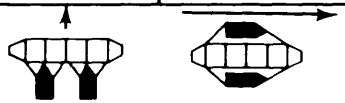
| | FREE LAUNCH | CONTROLLED LAUNCH | HIGH BANK LAUNCH |
|---|---|---|---|
| Minimum depth of water required CM (in) | Ramp bay 112 (44) Interior 92 (36) bay (Note 1) | 76 (30) (Note 2) | 76 (30) (Note 2) |
| Bank height restrictions M (ft) | 0-1 5 (0-5) | 0 | 1 5 - 8 5 (5 - 28) |
| Bank slope restrictions | 0 - 30% | 0 - 0% | Level ground unless the front of the truck is restrained |

NOTE:

1. The launch is based upon a 10 percent slope with the transporter backed into the water The required water depth for a 30 percent slope with a 5 foot bank height is 183CM (72 in). Interpolate between these values when needed.
2. This is recommended water depth launch could technically be conducted in 43CM (17 in) of water.

**Table 7-6. Ribbon raft design**

| CAPABILITIES | ASSEMBLY TIME | LOAD SPACE | CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Raft: | (Increase by 50% at night) | M (FT) | | 0.9<br>0.3 | 1.2<br>4 | 1.5<br>5 | 1.75<br>6 | 2<br>7 | 2.5<br>8 | 2.7<br>9 | 3<br>10 |
| 3 bay<br>(2 ramps/1 interior) | 8 min | 6.7<br>(22) | L<br>C | 45<br>45 | 45<br>45 | 45<br>35 | 40<br>25 | 40<br>15 | 35<br>10 | 30<br>0 | 25<br>0 |
| 4 bay<br>(2 ramps/2 interiors) | 12 min | 13<br>(44) | L<br>C | 70<br>60 | 70<br>60 | 70<br>60 | 60<br>*55 | 60<br>*40 | 60<br>*30 | 55<br>*15 | 45<br>0 |
| 5 bay<br>(2 ramps/3 interiors) | 15 min | 20.1<br>(66) | L<br>C | 75<br>75 | 75<br>70 | 75<br>70 | 70<br>*70 | 70<br>*60 | 70<br>*50 | 60<br>*25 | 60<br>0 |
| 6 bay<br>(2 ramps/4 interiors) | 20 min | 26.8<br>(88) | L<br>C | W96/<br>T80<br>W96/<br>T75 | 96/<br>80<br>96/<br>70 | 96/<br>80<br>96/<br>70 | 96/<br>70<br>*70/<br>70 | 96/<br>70<br>*70/<br>70 | 96/<br>70<br>*55/<br>55 | 70/<br>70<br>*30/<br>30 | 70<br>70<br>0 |




NOTES: 1. The asterisk (*) indicates that 3 bridge erection boats are required for conventional rafting of 4 5. or 6 bay rafts in currents greater than 1.5MPS/ 5 FPS.

2. When determining raft classification. L refers to longitudinal rafting and C refers to conventional rafting.

3. If the current velocity in the loading/unloading areas is greater than 1.5MPS/ 5 FPS, then conventional rafting must be used.

4. The roadway width of a Ribbon raftis is 4.1M (13 ft 5 in).

5. The draft of a fully loaded Ribbon raft is 61CM (24 in).

6. NEVER load vehicles on Ribbon ramp bays. Only interior bays may be loaded.

*Bridge design.* The number of Ribbon interior bays requlred are–

$$\frac{\text{gap (meters)} - 14}{6.7} = \text{number of interior bays}$$

OR

$$\frac{\text{gap(feet)} - 45}{22} = \text{number of interior bays}$$

■ Two ramp bays are required for all Ribbon bridges.

■ During daylight hours a Ribbon bridge can be constructed at the rate of 200 meters (600 feet) per hour (Add 50 percent at n!ght.) See Table 7-7 for bridge classification.

**Table 7-7. Determination of bridge classification (wheel/track)**

| TYPE OF CROSSING | CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0·9 0 3 | 1 2 4 | 1.5 5 | 1 75 6 | 2 7 | 2 5 8 | 2 7 9 | 3 10 |
| Normal (W/T) | 96/ 75 | 96/ 75 | 96/ 70 | 96/ 70 | 82/ 70 | 65/ 60 | 45/ 45 | 30/ 30 |
| Cautron (W/T) | 105/ 85 | 105/ 85 | 100/ 80 | 100/ 80 | 96/ 80 | 75/ 65 | 50/ 50 | 35/ 35 |
| Risk (W/T) | 110/ 100 | 110/ 95 | 105/ 90 | 105/ 90 | 100/ 90 | 82/ 75 | 65/ 65 | 40/ 40 |

■ Anchorage of Ribbon bridges is normally accomplished by tying BEBs to the downstream slde of rhe bridge. The number of boats required is shown in Table 7- 8.

**Table 7-8. Determination of number of boats needed for the anchorage of a Ribbon bridge**

| CURRENT VELOCITY (MPS/FPS) | NUMBER OF BOATS : NUMBER OF BRIDGE BAYS |
|---|---|
| 0 · 1 8/0 · 6 | 1 : 6 |
| 2 1 2 5 7 8 | 1 : 3 |
| 2 7/9 | 1 : 2 |
| Over 2.7/Over 9 | Bridge must be anchored using an overhead cable system. |

## M4T6 Floating Aluminum Bridge

### Allocation

Each corps float brldge company (M4T6) has five sets of M4T6 and 10 BEBs. One set provides – 141 feet (43 meters) normal bridge.

OR

96 feet (29 meters) reinforced bridge,

OR

one 4 float normal raft,

OR

one 5 float normal raft,

OR

one 4-float reinforced raft and one 5-float reinforced raft,

OR

one 6 float reinforced raft.

### Transportation

The M4T6 is normally transported using 5-ton bridge trucks. One bay of bridge disassembled, can be loaded on one 5-ton truck. Bays can also be preassembled and flown to the river, using medium lift helicopters.

### Raft design

**Table 7-9. M4T6 raft design and determination of raft classification (wheel track)**

| RAFT | LOAD SPACE M (FT) | CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS | | | | ASSEMBLY TIMES |
|---|---|---|---|---|---|---|
| | | 1.5 / 5 | 2 / 7 | 2.5 / 8 | 3.5 / 11 | |
| 4-float normal | 15.7 (51.6) | 50 / 55 | 45 / 50 | 40 / 45 | 30 / 35 | Per 4-float raft: · 5 brg trucks · 2 BEB-SD · 1 plt, 2¼ hr (when preassembled, 1¼ hr) |
| 5-float normal | 20.3 (66.6) | 55 / 60 | 50 / 55 | 45 / 50 | 35 / 40 | |
| 4-float reinforced | 11.6 (38.3) | 50 / 55 | 50 / 55 | 45 / 50 | 35 / 40 | Per 5-float raft: · 6 brg trucks · 2 BEB-SD · 1 plt, 3 hr (when preassembled, 1½ hr) |
| 5-float reinforced | 15.2 (50) | 60 / 65 | 60 / 65 | 55 / 60 | 45 / 50 | |
| 6-float reinforced | 16.2 (53.3) | 65 / 70 | 65 / 70 | 65 / 70 | 45 / 50 | Per 6-float raft: · 7 brg trucks · 2 BEB-SD · 1 plt, 3¼ hr (when preassembled, 1¼ hr) |

NOTES: 1. Refer to TM 5210 for methods of constructing M4T6 rafts.
2. Roadway width of an M4T6 raft is 4.2M (13 ft 10 in).
3. Draft of a fully loaded M4T6 raft is 66CM (29 in).
4. Construction times increase by 50 percent at night.

**Bridge design**

Floats (bays) required for normal bridges are—

$$\left(\frac{\text{gap (meters)}}{4.6} + 2\right) \times 1.1$$

OR

$$\left(\frac{\text{gap (feet)}}{15} + 2\right) \times 1.1$$

(Round UP to next whole number)

Floats required for **reinforced bridges** are–

$$\left(\frac{\text{gap (meters)}}{3}\right) \times 1.1$$

OR

$$\left(\frac{\text{gap (feet)}}{10}\right) \times 1.1$$

(Round UP to a number divisible by 3)

NOTE: For reinforced bridges, two-thirds of the total number of floats must be equipped with offset saddle adaptors.

**Site and personnel requirements.**

**Table 7-10. Determination of site and personnel requirements**

| LENGTH (Normal Assy) M (FT) | UNITS NEEDED FOR ASSY | NUMBER OF ASSY SITES | TIME (HR) |
|---|---|---|---|
| 45.5 (150) | 1 Company | 2 | 4 |
| 61 (200) | 1 Company | 2 | 5 |
| 76 (250) | 1 Company | 2 | 6 |
| 91.5 (300) | 2 Companies | 3 | 4 |
| 106.5 (350) | 2 Companies | 3 | 5 |
| 122 (400) | 2 Companies | 4 | 5½ |
| 152 (500) | 2 Companies | 5 | 6 |
| 183 (600) | 3 Companies | 6 | 4 |
| 213 (700) | 3 Companies | 6 | 5-7 |
| 244 (800) | 3 Companies | 6 | 6-8 |
| 305 (1.000) | 3 Companies | 6 | 7-10 |
| 366 (1.200) | 3 Companies | 6 | 8-12 |

NOTES:1. Refer to TM 5-210 for methods of constructing M4T6 bridges.
2. Increase construction times by 50 percent for reinforced bridges.
3. Increase all construction times by 50 percent at night.
4. Draft of an M4T6 bridge is 101.6CM (40 in).

**Bridge classifications.**

**Table 7-11. Determination of bridge classification** (wheel/track) for M4T6 normal and M4T6 reinforced bridges

| M4T6 NORMAL BRIDGE | | | | | M4T6 REINFORCED BRIDGE | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS | | | | | CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS | | | |
| TYPE CROSSING | 1.5 / 5 | 2 / 7 | 2.5 / 8 | 3.5 / 11 | TYPE CROSSING | 1.5 / 5 | 2 / 7 | 2.5 / 8 | 3.5 / 11 |
| Normal (W/T) | 45 / 55 | 40 / 50 | 35 / 45 | 25 / 30 | Normal (W/T) | 75 | 70 / 75 | 65 / 70 | 27 / 30 |
| Caution (W/T) | 58 / 59 | 54 / 55 | 49 / 51 | 35 / 37 | Caution (W/T) | 80 | 79 | 73 | 43 / 45 |
| Risk (W/T) | 66 / 67 | 62 / 63 | 59 / 60 | 43 / 45 | Risk (W/T) | 90 | 90 | 87 | 59 / 60 |

## Class 60 Steel Floating Bridge

One standard bridge set contains the components for the complete assembly of one floating brldge capable of spanning a 135-foot (41-meter) gap OR one 4-, 5-, or 6- bay raft.

### Transportation

Class 60 bridges may be palletized and loaded on M172 semitrailers. Additionally, one 15-foot bay of bridge may be transported on one 5-ton bridge truck.

**Raft design**

**Table 7-12. Class 60 raft design and determination of** raft classification (wheel/track)

| RAFT | LOAD SPACE M (FT) | CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS | | | |
|---|---|---|---|---|---|
| | | 1.5 / 5 | 2 / 7 | 2.5 / 8 | 3.5 / 11 |
| 4-float normal | 15 (51) | 40 / 45 | 40 / 45 | 35 / 40 | 25 / 30 |
| 5-float normal | 20 (66) | 50 / 55 | 50 / 55 | 45 / 50 | 40 / 45 |
| 5-float reinforced | 15 (51) | 55 / 60 | 50 / 55 | 50 / 55 | 45 / 50 |
| 6-float reinforced | 16 (54) | 65 / 75 | 65 / 75 | 65 / 70 | 50 / 50 |

NOTES: 1. Refer to TM 5-210 for methods of constructing Class 60 rafts.
2. One air compressor, one crane, and two bridge erection boats are needed for raft construction and propulsion.
3. Roadway width of a Class 60 raft is 4.1M (13 ft 6 in)
4. Draft of a fully loaded Class 60 raft is 73.6CM (29 in).

### Bridge design

**Floats (bays) required for normal bridges are—**

$$\left(\frac{\text{gap (meters)}}{4\ 6}\right) \times 1\ 1 = \text{number of floats}$$

OR

$$\left(\frac{\text{gap (feet)}}{15}\right) \times 1\ 1 = \text{number of floats}$$

(Round UP to next higher number.)

Floats (bays) required **for normal bridges with reinforced end spans** are–

$$\left(\frac{\text{gap (meters)}}{4.6} + 2\right) \times 1.1 = \text{number of floats}$$

OR

$$\left(\frac{\text{gap (feet)}}{15} + 2\right) \times 1.1 = \text{number of floats}$$

(Round UP to next whole number

**Site and personnel requirements.**

**Table 7-13. Class 60 bridge site and personnel requirements**

| BRIDGE LENGTH M (FT) | UNITS REQUIRED FOR ASSEMBLY | NUMBER OF ASSY SITES | TIME (HR) |
|---|---|---|---|
| 0-75 (0-250) | 1 company | 2 | 3 |
| 76-160 (251-525) | 2 companies | 3-5 | 3-5 |
| 161-300 (526-1,000) | 1 battalion plus 2 companies | 6 | 5-8 |

NOTES: 1. Refer to TM 5-210 for methods of constructing Class 60 bridges.
2. One air compressor, one crane, and two bridge erection boats are required at each assembly site.
3. Roadway width of a Class 60 bridge is 4.1M (13 ft 6 in)
4. Draft of a Class 60 bridge is 101.6CM (40 in).
5. Construction time increases by 50 percent at night.

**Bridge classifications.**

**Table 7-14. Bridge classification (wheel/track)**

| CLASS 60 NORMAL BRIDGE | | | | | CLASS 60 NORMAL BRIDGE W/REINFORCED END SPANS | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS | | | | | CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS | | | |
| TYPE CROSSING | 1.5 / 5 | 2 / 7 | 2.5 / 8 | 3.5 / 11 | TYPE CROSSING | 1.5 / 5 | 2 / 7 | 2.5 / 8 | 3.5 / 11 |
| Normal (W/T) | 55 | 45/55 | 40/50 | 22/25 | Normal (W/T) | 55/65 | 45/55 | 40/50 | 22/25 |
| Caution (W/T) | 60 | 56/60 | 52/56 | 34/37 | Caution (W/T) | 62/67 | 56/61 | 52/56 | 34/37 |
| Risk (W/T) | 70 | 67/70 | 62/67 | 46/50 | Risk (W/T) | 72/77 | 67/72 | 62/67 | 46/50 |

NOTE: Classifications are based upon a 15 ft end span. Refer to TM 5-210 for bridges with longer end spans.

## Light Tactical Raft (LTR)

One set of LTR can provide–

one 4-ponton, 3-bay raft,

OR

one 4-ponton, 4-bay raft,

OR

44 feet (13.4 meters) of bridge.

### Transportation

One set of LTR is transported on two 2 ½-ton trucks and one pole trailer

**Table 7-15. Raft/bridge design and classification determinatlon**

| RAFT | ASSEMBLY TIME | LOAD SPACE M (FT) | CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1.5<br>5 | 2<br>7 | 2.5<br>8 | 2.75<br>9 | 3<br>10 | 3.5<br>11 |
| 4-ponton/3-bay w/articulators | 30 min | 9.15 (30) | 12 | 12 | 12 | 8 | 4 | 0 |
| 4-ponton/3-bay w/o articulators | 25 min | 9.15 (30) | 16 | 16 | 12 | 8 | 4 | 0 |
| 4-ponton/4-bay w/articulators | 36 min | 12.5 (41) | •10 | 10 | 10 | 6 | 2 | 0 |
| 5-ponton/5-bay w/ articulators | 40 min | 15.85 (52) | 9 | 9 | 9 | 8 | 5 | 2 |
| 5-ponton/5-bay w/o articulators | 35 min | 15.85 (52) | 16 | 14 | 11 | 8 | 5 | 2 |
| 6-ponton/4-bay w/articulators | 45 min | 12.5 (41) | 13 | 13 | 13 | 13 | 12 | 5 |
| 6-ponton/5-bay w/o articulators | 45 min | 15.85 (52) | 18 | 18 | 18 | 18 | 12 | 6 |
| BRIDGE | 150 ft/hr<br>45.7M/hr | NA | 16 | 13 | 11 | 8 | 5 | 2 |

NOTES:
1. Refer to TM 5-210 for methods of construction.
2. Articulators allow the ramps to be adjusted up 1M (41 in) or down .48M (19 in).
3. Roadway width is normally 9 ft.
4. All classifications are based upon a Normal crossing.
5. Construction times increase by 50 percent at night.
6. The draft of a LTR raft with outboard motors is 61CM (24 in).
7. To determine the number of LTR sets required to bridge a given gap, use the formula:

$$\frac{\text{Gap (M)}}{14} = \text{number of sets OR} \quad \frac{\text{Gap (ft)}}{44} = \text{number of sets.}$$

## Long-Term Anchorage Systems

All heavy floating bridges require the construction of long-term anchorage systems. All long-term anchorage systems include three baste components approach guys, upstream (primary) anchorage, and downstream (secondary) anchorage. Refer to TM 5-210 for additional information.

### Approach guys

Approach guys are attached at one end to the first floating support of all floating bridges. The approach guy is secured at the other end using deadmen, pickets, or natural holdfasts. A minimum of ½ inch Improved Plough Steel (IPS) cable should be used. When installed, the approach guys should form a 45-degree angle with the bridge.

### Upstream anchorage

See Table 7-16. The upstream anchorage system holds the bridge in position against the river's main current. Upstream anchorage systems should be designed based primarily upon current velocity and bottom conditions.

**Table 7-16. Design of upstream (primary) anchorage systems**

| CURRENT VELOCITY (MPS/FPS) | BOTTOM CONDITIONS | |
|---|---|---|
| | SOFT | SOLID/ROCKY |
| 0-0.9/0-3 | Kedge anchors every float upstream or shore guys every 6th float upstream | Shore guys every 6th float upstream |
| 1.0-1.5/3.1-5 | Combination system (kedge anchors and shore guys) | Overhead cable system |
| 1.6-3.5/5.1-11 | Overhead cable system | Overhead cable system |

### Downstream anchorage

The downstream anchorage system protects floating bridges from reverse currents (tides) as well as from storms or severe winds which might change the direction of river flow.

**Table 7-17. Design of downstream (secondary) anchorage systems**

| REVERSE CURRENT (MPS/FPS) | BOTTOM CONDITIONS | |
|---|---|---|
| | SOFT | SOLID/ROCKY |
| None expected | Kedge anchors every 3d float downstream or shore guys every 10th float downstream | Shore guys every 10th float downstream |
| 0-0.9/0-3 | Kedge anchors every float downstream or shore guys every 6th float downstream | Shore guys every 6th float downstream |
| 1.0-1.5/3.1-5 | Combintion system (kedge anchors and shore guys) | Overhead cable system |
| 1.6-3.5/5.1-11 | Overhead cable system | Overhead cable system |

## Installation

**Table 7-18. Installation of long-term anchorage systems**

| SYSTEM | METHOD OF INSTALLATION |
|---|---|
| Kedge anchor system | 1. Attach anchors to anchor lines. Anchor lines must be a minimum of 1" manila rope.<br>2. Set or lay anchors. The horizontal distance from the anchor to the float must be at least 10 times the depth of the river.<br>3. Attach anchor lines to floats. |
| Shore guy system | 1. Attach shore guys to floats.<br>2. Shore guys must be a minimum of ½" Improved Plough Steel (IPS) cable and placed at an angle of 45° with the bridge.<br>3. Shore guys must be held above the water. Use floating supports if necessary.<br>4. Attach shore guys to deadman or holdfasts. |
| Combination system | 1. Emplace a kedge anchor system as described above. Anchor lines must be attached to every float.<br>2. Once kedges are installed, emplace a shore guy system as described above. Shore guys must be attached to every sixth float. |
| Overhead cable system | 1. Design the system.<br>2. Construct Class 60 towers and install deadman.<br>3. Install master cable. Check initial sag.<br>4. Using bridle lines, attach every float to the master cable. |

## Design

The following information must be calculated or determined when designing an overhead cable anchorage system:

1. Cable data

Number of master cables. . . . . .
Size of master cable(s) ($C_D$) . . . . . .
Length of the master cable(s) ($C_L$). . . . . .
Number of clips at each end of the cable. . . . . .
Spacing of cable clips . . . . . .
Initial sag (S) . . . . . .

2. Tower data

Actual tower height (H)
near shore. . . . . .
far shore . . . . . .

Tower-waterline distance (A)
near shore . . . . . .
far shore. . . . . .

Tower-bridge offset ($O_t$)
near shore. . . . . .
far shore. . . . . .

3. Deadman data

Depth of deadman ($D_D$)
near shore . . . . . .
far shore . . . . . .
Tower-deadman distance (C)
near shore . . . . . .
far shore . . . . . .
Tower-deadman offset ($O_2$)
near shore . . . . . .
far shore . . . . . .
Deadman face ($D_F$) . . . . . .
Deadman thickness (D) . . . . . .
Deadman length ($D_L$)
near shore . . . . . .
far shore . . . . . .
Bearing plate thickness (x) . . . . . .
Bearing plate length (y) . . . . . .
Bearing plate face (z) . . . . . .

**Design sequence**

Use Figure 7-1 to determine where to take the required measurements for an overhead cable anchorage system.

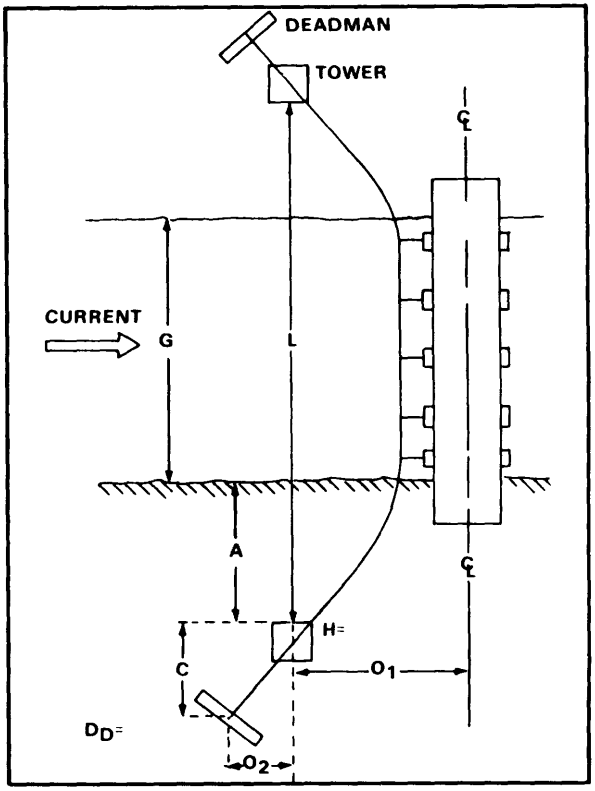



**Figure 7-1. Dimensions for overhead cable design**

Step 1. Determine the size and number of master cables required. See Table 7-19 for M4T6, Class 60, and Ribbon bridges. See Table 7-20 for light tactical bridges.

Number of cables = . . . . . .

$C_o$ = . . . . . ..

**Table 7-19. Determination of cable size ($C_o$) and number of cables**
for M4T6, Class 60, and Ribbon bridges

| WET GAP WIDTH (G) FEET | TYPE BRIDGE ASSEMBLY | SIZE (IN) AND NUMBER OF CABLES FOR SPECIFIED RIVER VELOCITIES | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 FPS | | | 7 FPS | | | 9 FPS | | | 11 FPS | | |
| | | SINGLE | DUAL | TRIPLE | SINGLE | DUAL | TRIPLE | SINGLE | DUAL | TRIPLE | SINGLE | DUAL | TRIPLE |
| 200 | Normal | 1/2 | 3/8 | 3/8 | 5/8 | 1/2 | 1/2 | 3/4 | 5/8 | 1/2 | 7/8 | 3/4 | 5/8 |
| | Reinforced | 5/8 | 1/2 | 3/8 | 3/4 | 5/8 | 1/2 | 7/8 | 3/4 | 5/8 | 1 1/8 | 7/8 | 3/4 |
| 400 | Normal | 5/8 | 1/2 | 1/2 | 3/4 | 5/8 | 1/2 | 1 | 7/8 | 5/8 | 1 1/4 | 1 | 3/4 |
| | Reinforced | 3/4 | 5/8 | 1/2 | 1 | 3/4 | 5/8 | 1 1/4 | 1 | 3/4 | 1 1/2 | 1 1/4 | 7/8 |
| 600 | Normal | 3/4 | 5/8 | 1/2 | 1 | 3/4 | 5/8 | 1 1/4 | 1 | 3/4 | 1 1/2 | 1 1/4 | 7/8 |
| | Reinforced | 1 | 3/4 | 5/8 | 1 1/8 | 1 | 3/4 | 1 1/2 | 1 1/4 | 7/8 | * | 1 1/2 | 1 1/8 |
| 800 | Normal | 7/8 | 3/4 | 5/8 | 1 1/8 | 7/8 | 3/4 | 1 3/8 | 1 1/8 | 7/8 | * | 1 1/2 | 1 1/8 |
| | Reinforced | 1 1/8 | 7/8 | 3/4 | 1 3/8 | 1 1/8 | 7/8 | * | 1 3/8 | 1 | * | * | 1 1/4 |
| 1.000 | Normal | 1 | 7/8 | 3/4 | 1 1/4 | 1 | 7/8 | 1 1/2 | 1 3/8 | 1 | * | * | 1 1/4 |
| | Reinforced | 1 1/4 | 1 | 3/4 | 1 1/2 | 1 1/4 | 1 | * | * | 1 1/8 | * | * | 1 3/4 |
| 1.200 | Normal | 1 1/8 | 7/8 | 3/4 | 1 3/8 | 1 1/8 | 7/8 | * | 1 1/2 | 1 1/8 | * | * | 1 3/8 |
| | Reinforced | 1 3/8 | 1 1/8 | 7/8 | * | 1 3/8 | 1 | * | * | 1 1/4 | * | * | * |

NOTES: 1. All values are based upon IPS cable and a 2 percent initial sag.
2. Asterisks (*) indicate that is is unsafe to construct that system.

Step 2. Determine the distance between towers (L) in feet.

L = 1.1 (G) + 100' L = . . . . . .

Where G = the width of the wet gap in feet

**Table 7-20. Determination of cable size ($C_D$) for light tactical bridges**

| WET GAP WIDTH (G) FEET | CURRENT VELOCITY | | | |
|---|---|---|---|---|
| | 5 FPS | 7 FPS | 9 FPS | 11 FPS |
| 200 | 3/8 | 3/8 | 1/2 | 1/2 |
| 300 | 3/8 | 1/2 | 5/8 | 3/4 |
| 400 | 1/2 | 1/2 | 5/8 | 3/4 |
| 500 | 1/2 | 5/8 | 5/8 | 3/4 |
| 600 | 5/8 | 5/8 | 3/4 | 7/8 |

NOTE: All values are based upon IPS cable and a 2 percent sag.

Step 3. Determine the length of the master cable ($C_L$) in feet.

$C_L = L + 250'$ $C_L =$ . . . . . .
Where L = the distance between towers in feet

NOTE. This is an approximation based upon the most extreme circumstances

Step 4. Determine the number of cable clips required to secure one end of the master cable.

Number of clips = $(3 \times C_D) + 1$ Number of clips at each end = . . . . . .
Where $C_D$ = the cable diameter in inches

Step 5. Determine the spacing of cable clips in inches

Clip spacing = $6 \times C_D$ Clip spacing = . . . . . .
Where $C_D$ = the cable diameter in inches

Step 6. Determine initial sag (S) in feet.

S = .02(L) S = . . . . . ...
Where L = the distance between towers in feet

Step 7. Determine tower height (H) in feet.

a. $H_R = 3' + S - BH$
Where $H_R$ = the REQUIRED tower height in feet
S = initial sag in feet
BH = bank height in feet

NOTE. This calculation must be done for both the near shore and the far shore since bank heights may be different.

b. Determine actual tower height (H). See Table 7-21 Compare the required tower height to the possible tower height. Select the smallest possible tower that is greater than or equal to the required height.

NOTE. If the near shore and the far shore towers are determined to have different heights, steps 9 through 16 must be calculated separately for both near and far shores.

H near shore = . . . . . .
H far shore = . . . . . .

**Table 7-21. Possible tower heights (H)**

| NUMBER OF TOWER SECTIONS | TOWER HEIGHT (H) |
|---|---|
| Cap, base, and pivot unit | 3' 8 1/4" |
| With 1 tower section | 14' 6 1/4" |
| With 2 tower sections | 25' 4 1/4" |
| With 3 tower sections | 36' 2 1/4" |
| With 4 tower sections | 47' 1/4" |
| With 5 tower sections | 57' 10 1/4" |
| With 6 tower sections | 68' 8 1/4" |

Step 8. Determine the distance from each tower to the waterline (A) in feet.

$$A = \frac{L-G}{2}$$

A near shore

A far shore

Where L = the distance between towers in feet

G = the gap width in feet

Step 9. Determine the offset from each tower to the bridge centerline ($0_L$) in feet

$0_L$ near shore = . . . . . .

$0_L$ far shore = . . . . . .

a. If the bank height (BH) is less than or equal to 15', then $O_L$ = H + 50'.

b. If the bank height (BH) is greater than 15', then $0_L$ = H + BH + 35'.

Where H = the actual tower height in feet

BH = the bank height in feet

Step 10. Identify deadman dimensions. Select a deadman from the available timbers and logs. Generally, the timber with the largest timber face/log diameter is selected. The largest face of the deadman is defined as $D_f$, and the thickness is $D_t$.

$D_f$ = . . . . . .

$D_t$ = . . . . . .

Step 11. Determine mean depth of deadman ($D_D$) in feet.

$D_D$ near shore = . . . . . .

$D_D$ far shore = . . . . . .

a. There must be a minimum of 1 foot of undisturbed soil between the bottom of the deadman and the ground water level (GWL). The deepest the deadman can be ($D_{Dmax}$) is calculated as:

$$D_{Dmax} = GWL - 1' - \frac{D_f}{2}$$

Where $D_f$ = the deadman face in feet

GWL = depth of ground water level in feet

b. The minimum deadman depth is always 3 feet

c. The maximum deadman depth is always 7 feet

d. Compare $D_{Dmax}$ to these minimum and maximum values to determine the actual mean depth of deadman ($D_D$).

Step 12. Determine length of deadman ($D_L$) in feet.

$$D_L = \left( \frac{CC}{HP \times D_f} \right) + 1$$

$D_L$ near shore = . . . . . .

$D_L$ far shore = . . . . . .

Where CC = the capacity of the anchorage cable in lb/1,000 from Table 7-22

HP = required holding power in lb/1,000 sq ft from Table 7-23

$D_f$ = deadman face in feet (for log deadman use log diameter (d))

**Table 7-22. Determination of capacity of anchorage cable (CC) in lb/1,000**

| TYPE OF CABLE | SIZE (IN) OF CABLE ($C_D$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 3/8 | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 3/8 | 1 1/2 |
| IPS | 1.26 | 21.6 | 33.2 | 47.4 | 64.4 | 84.0 | 106.0 | 130.0 | 157.0 | 185.0 |
| PS | 11.0 | 18.8 | 28.8 | 41.2 | 56.0 | 73.0 | 92.0 | 113.0 | 136.0 | 161.0 |
| MPS | 10.0 | 17.0 | 26.2 | 37.4 | 50.8 | 66.0 | 83.0 | 102.0 | 123.0 | 145.0 |

**Table 7-23. Determination of required holding power (HP)**
in lb/1,000 sq ft

| DEPTH OF DEADMAN ($D_D$) FEET | TOWER TO DEADMAN SLOPE | | | |
|---|---|---|---|---|
| | 1:1 | 1:2 | 1:3 | 1:4 |
| 3 | .95 | 1.3 | 1.45 | 1.5 |
| 4 | 1.75 | 2.2 | 2.6 | 2.7 |
| 5 | 2.8 | 3.6 | 4.0 | 4.1 |
| 6 | 3.8 | 5.1 | 5.8 | 6.0 |
| 7 | 5.1 | 7.0 | 8.0 | 8.4 |

Step 13. Check minimum thickness of deadman ($D_t$) in feet

For timber: $\frac{D_o}{D_t}$ must be less than or equal to 9

For logs: $\frac{D_o}{d}$ must be less than or equal to 5

Step 14. Determine the tower to deadman distance (C) in feet.

$$C = \frac{H + D_o}{\text{slope}}$$

C near shore = . . . . . .
C far shore = . . . . . .

Where H = the actual tower height in feet
$D_o$ = the mean depth of deadman in feet
slope = the tower to deadman slope

Step 15. Determine the tower to deadman offset ($O_2$) in feet.

$$O_2 = (C(O_2'))$$

$O_2$ near shore = . . . . . .
$O_2$ far shore = . . . . . .

Where C = the tower to deadman distance in feet
$O_2'$ = a factor determined from Table 7-24

**Table 7-24. Determination of $O_2'$**

| TYPE OF ASSEMBLY | CURRENT VELOCITY | | | | |
|---|---|---|---|---|---|
| | 3 FPS | 5 FPS | 7 FPS | 9 FPS | 11 FPS |
| Normal | .09 | .11 | .14 | .17 | .19 |
| Reinforced | .11 | .14 | .17 | .19 | .23 |

Step 16. Design a bearing plate for each deadman. Given deadman face ($D_t$) or log diameter (d) and the size of the master cable (CD), refer to Table 7-25 (page 7-20) to determine the length, thickness and face of the deadman bearing plate.

x = . . . . . .
y = . . . . . .
z = . . . . . .

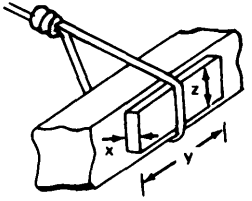
**Table 7-25. Determination of bearing plate dimensions**

x, y, and z (inches)

| DEADMAN FACE ($D_f$) | | CABLE SIZE ($C_D$) (IN INCHES) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 3/8 | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 1/2 |
| 8 | x | 7/16 | 7/8 | 1 1/4 | | | | | | |
| | y | 4 | 8 | 11 | | | | | | |
| | z | 6 | 6 | 6 | | | | | | |
| 10 | x | 7/16 | 11/16 | 1 | 1 3/8 | | | | | |
| | y | 4 | 6 | 9 | 12 | | | | | |
| | z | 8 | 8 | 8 | 8 | | | | | |
| 12 | x | 7/16 | 9/16 | 13/16 | 1 1/8 | 1 7/16 | | | | |
| | y | 4 | 5 | 7 | 10 | 13 | | | | |
| | z | 10 | 10 | 10 | 10 | 10 | | | | |
| 14 | x | 7/16 | 7/16 | 11/16 | 7/8 | 1 1/4 | 1 9/16 | 2 | | |
| | y | 4 | 4 | 6 | 8 | 11 | 14 | 18 | | |
| | z | 12 | 12 | 12 | 12 | 12 | 12 | 12 | | |
| 16 | x | 7/16 | 7/16 | 9/16 | 13/16 | 1 1/8 | 1 3/8 | 1 11/16 | 2 1/8 | |
| | y | 4 | 4 | 5 | 7 | 10 | 12 | 15 | 19 | |
| | z | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | |
| 18 | x | 7/16 | 7/16 | 7/16 | 11/16 | 7/8 | 1 1/4 | 1 9/16 | 1 13/16 | |
| | y | 4 | 4 | 4 | 6 | 8 | 11 | 14 | 16 | |
| | z | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | |
| 20 | x | 7/16 | 7/16 | 7/16 | 11/16 | 7/8 | 1 1/8 | 1 3/8 | 1 11/16 | |
| | y | 4 | 4 | 4 | 6 | 8 | 10 | 12 | 15 | |
| | z | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | |
| 24 | x | 7/16 | 7/16 | 7/16 | 9/16 | 11/16 | 7/8 | 1 1/8 | 1 3/8 | 1 7/8 |
| | y | 4 | 4 | 4 | 5 | 6 | 8 | 10 | 12 | 17 |
| | z | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |

NOTE: The values in this table are based upon the use of IPS cable. For former bearing plates refer to TM 5-210.

Where x = bearing plate thickness
y = bearing plate length
z = bearing plate face




## M4T6 FIXED SPAN

Refer to TM 5-210 for more detailed information.

### Single Span Bridge

Single span bridge design is for 15 feet to 45 feet unsupported H-frames.

1. Classification of bridge (designated in the mission statement). 1. CL ____

2. Gap as measured during reconnaissance. 2. ____

3. Safety setback for near shore (NS) and far shore (FS) is a constant of 3' for both prepared and unprepared abutments. 3a. NS+3' 3b. FS+3'

4. Initial bridge length (add steps 2, 3a, and 3b). 4.= ____

5. Round UP to next highest standard H-frame configuration (Table 7-26) 5. _____

6. Determine deck/roadway (D/R) ratio required to carry load (Table 7-26) 6. _____

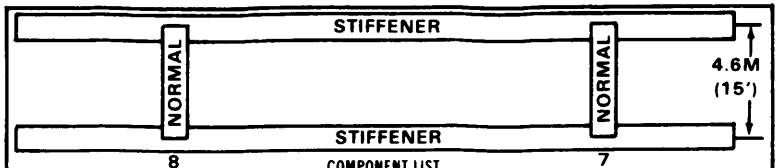
7. Final design of bridge
   a. H-frame (from step 5) 7a. _____
   b. D/R roadway ratio (from step 6) 7b. _____
   c. Classification (Table 7-26) 7c. _____

**Table 7-26. Deck balk fixed span data**

| CAPACITY FOR SPECIFIED SPAN LENGTH IN METERS (FT) AND DECK/ROADWAY RATIO | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LENGTH | 4.6 (15) | | | 7.1 (23.4) | | 8.1 (30) | | | 11.7 (38.4) | | | | 13.7 (45) | | | | | |
| DECK WIDTH | 22 | 22 | 26 | 22 | 22 | 22 | 22 | 24 | 22 | 22 | 24 | 26 | 20 | 22 | 22 | 24 | 24 | 26 | 26 |
| ROADWAY WIDTH | 18 | 18 | 22 | 18 | 16 | 18 | 16 | 18 | 18 | 16 | 18 | 18 | 16 | 18 | 16 | 18 | 16 | 18 | 16 |
| TYPE CROSSING | | | | | | | | | | | | | | | | | | | |
| Normal | 100 | 100 | 100 | 100 | 100 | 85 | 90 | 90 | 45 | 50 | 56 | 65 | 24 | 24 | 30 | 30 | 40 | 40 | 45 |
| | 100 | 100 | 100 | 100 | 100 | 65 | 70 | 70 | 35 | 40 | 45 | 50 | 25 | 25 | 30 | 30 | 35 | 35 | 40 |
| Caution | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 70 | 70 | 75 | 82 | 40 | 46 | 46 | 51 | 51 | 56 | 56 |
| | 100 | 100 | 100 | 100 | 100 | 80 | 80 | 85 | 51 | 51 | 55 | 50 | 35 | 40 | 40 | 43 | 43 | 46 | 46 |
| Risk | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 78 | 78 | 85 | 90 | 47 | 54 | 54 | 60 | 60 | 66 | 66 |
| | 100 | 100 | 100 | 100 | 100 | 90 | 90 | 95 | 57 | 57 | 62 | 67 | 40 | 45 | 45 | 49 | 49 | 53 | 53 |

22_ Deck Width
18 Roadway Width } Number of balk

NOTES:
I. Figures 7-2 through 7-6 show H-frame layout and components for all lengths of M4T6 unsupported spans.
2. All bridges require four short and four long cover plates if roadway is 18 balk wide. For 16 balk roadway use four long and two short cover plates. For 22 balk roadway use four long and eight short cover plates. All bridges require four bearing plates.

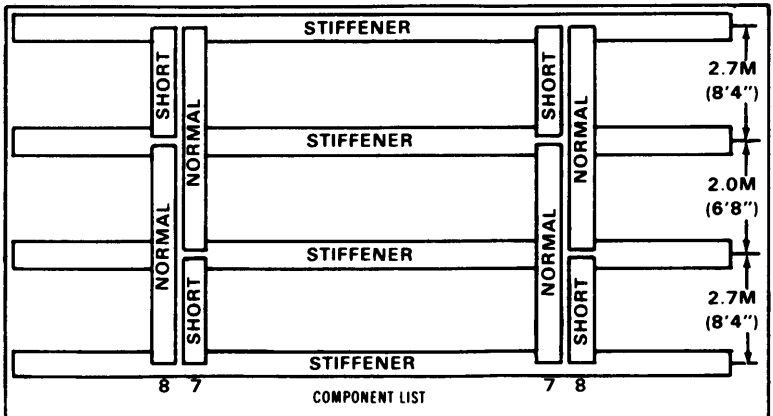



COMPONENT LIST

| LENGTH | 4.6M (15') | | |
|---|---|---|---|
| DECK/ROADWAY | 22/18 | 22/16 | 26/22 |
| Component | | | |
| Balk, normal | 22 | 22 | 26 |
| Balk, short | — | — | — |
| Balk, tapered (note) | 44 | 44 | 52 |
| Stiffeners | 2 | 2 | 2 |
| Pins, stiffener | 56 | 56 | 64 |
| Adapter, curb | 4 | 4 | 4 |

NOTE: Number of tapered balk may be reduced to quantity required to fill in ramps between curbs.

Figure 7-2. H-frame for 4.6M (15') fixed span



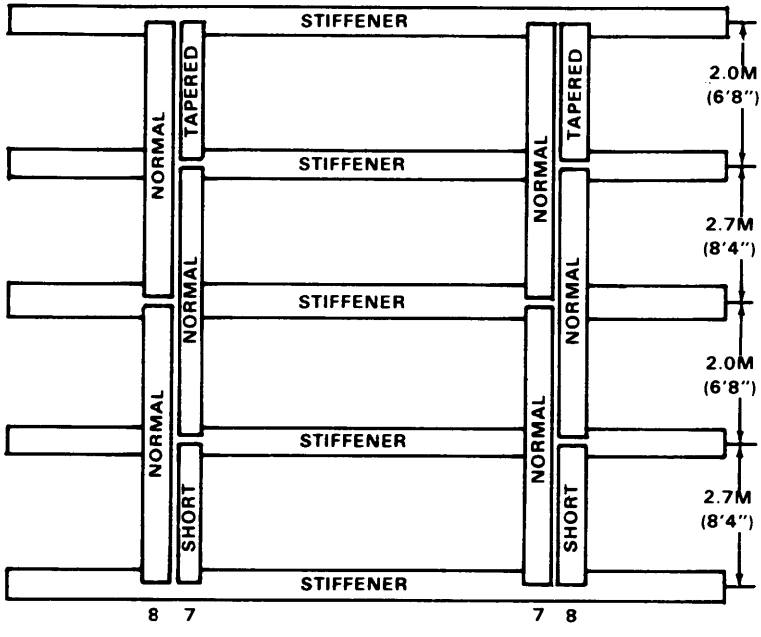

COMPONENT LIST

| LENGTH | 7.1M (23'4") | | 6.6M (21'8")[1] | |
|---|---|---|---|---|
| DECK/ROADWAY | 22/18 | 22/16 | 22/18 | 22/16 |
| Component | | | | |
| Balk, normal | 22 | 22 | 22 | 22 |
| Balk, short | 22 | 22 | — | — |
| Balk, tapered[2] | 44 | 44 | 66 | 66 |
| Stiffeners | 4 | 4 | 4 | 4 |
| Pins, stiffener | 104 | 104 | 104 | 104 |
| Adapter, curb | 8 | 8 | 8 | 8 |

NOTE: 1. Alternate to 7.1M (23'4"). Same class capability as 7.1M (23'4"). Use tapered balk in place of short balk.

2. Number of tapered balk may be reduced to quantity required to fill in ramps between curbs.

Figure 7-3. H-frame for 7.1M (23'4") fixed span

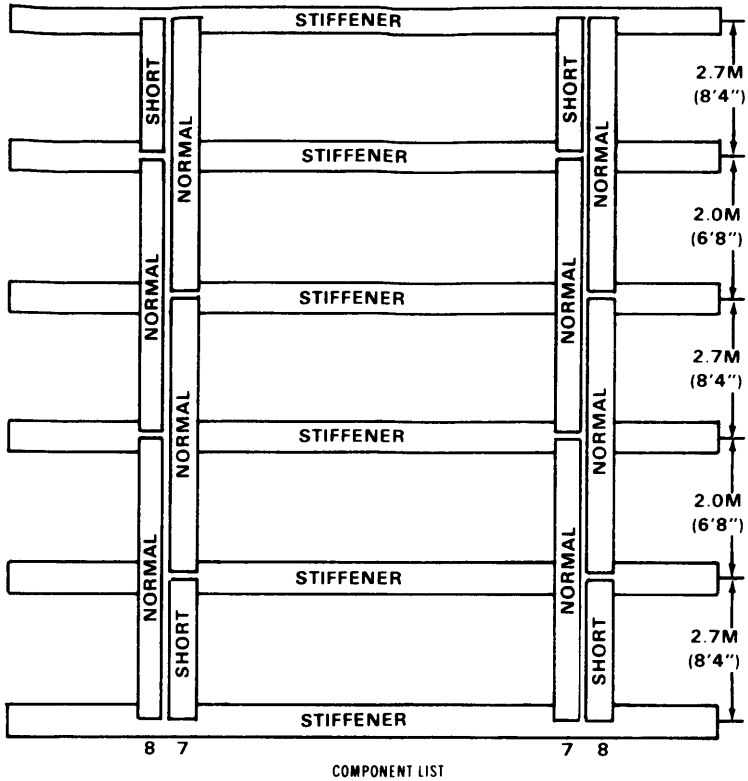



COMPONENT LIST

| LENGTH | 9.1M (30') | | |
|---|---|---|---|
| DECK/ROADWAY | 22/18 | 22/16 | 24/18 |
| Component | | | |
| Balk, normal | 33 | 33 | 35 |
| Balk, short | 22 | 22 | 22 |
| Balk, tapered (note) | 44 | 44 | 44 |
| Stiffeners | 5 | 5 | 5 |
| Pins, stiffener | 128 | 128 | 134 |
| Adapter, curb | 10 | 10 | 10 |

NOTE: Number of tapered balk may be reduced to quantity required to fill in ramps between curbs.

Figure 7-4. H-frame for 9.1M (30') fixed span



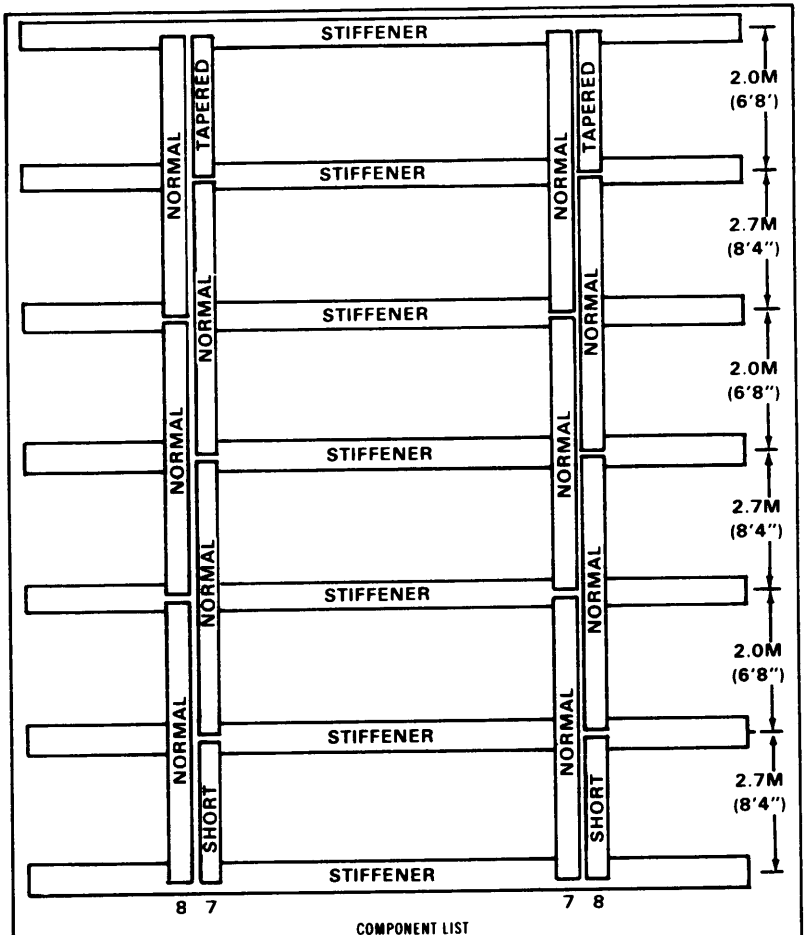

COMPONENT LIST

| LENGTH | 11.2M (36'8") [1] | | | | 11.7M (38'4") | | | |
|---|---|---|---|---|---|---|---|---|
| DECK/ROADWAY | 22/18 | 22/16 | 24/18 | 26/18 | 22/18 | 22/16 | 24/18 | 26/18 |
| Component | | | | | | | | |
| Balk, normal | 44 | 44 | 46 | 50 | 44 | 44 | 46 | 50 |
| Balk, short | 22 | 22 | — | — | 22 | 22 | 22 | 22 |
| Balk tapered [2] | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| Stiffeners | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Pins, stiffener | 152 | 152 | 158 | 158 | 152 | 152 | 158 | 168 |
| Adapter, curb | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |

NOTES: 1. Alternate to 11.7M (38'4"). Same class capability as 11.7M (38'4"). Use tapered balk in place of short balk.

2. Number of tapered balk may be reduced to quantity required to fill in ramps between curbs.

Figure 7-5. H-frame for 11.7M (38'4") fixed span




COMPONENT LIST

| LENGTH | 13.7M (45') | | | | | | |
|---|---|---|---|---|---|---|---|
| DECK/ROADWAY | 20/16 | 22/18 | 22/16 | 24/18 | 24/16 | 26/18 | 26/16 |
| Component | | | | | | | |
| Balk. normal | 50 | 52 | 52 | 57 | 57 | 61 | 61 |
| Balk. short | 11 | 10 | 10 | 11 | 11 | 11 | 11 |
| Balk. tapered (note) | 51 | 51 | 51 | 55 | 55 | 55 | 55 |
| Stiffeners | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Pins. stiffener | 162 | 172 | 172 | 182 | 182 | 192 | 192 |
| Adapter. curb | 14 | 14 | 14 | 14 | 14 | 14 | 14 |

NOTE: Number of tapered balk may be reduced to quantity required to fill in ramps between curbs.

Figure 7-6. H-frame for 13.7M (45') fixed span

## Class 60 Trestle Arrangement

M4T6 FIXED SPAN BRIDGE DESIGN
FOR SUPPORT WITH CLASS 60 TRESTLE ARRANGEMENT
(FOR CLASS 60 AND BELOW) WITH EXAMPLE FILLED IN

| | | | | |
|---|---|---|---|---|
| 1. Classification of the bridge that needs to be built (obtained from the mission statement). | 1. | MLC 60/60 | | |
| 2. Gap as measured during reconnaissance | 2. | 84' | | |
| 3. Safety setback for both the FS and NS is a constant of 3' for both prepared and unprepared abutments | 3a. | FS: + 3' | | |
| | 3b. | NS: + 3' | | |
| 4. Initial bridge length (add steps 2 + 3a + 3b) | 4. | = 90' | | |
| 5. Initially, enter the "2 trestle assemblies" column and subtract 15' from the total bridge length obtained in step 4. (This distance must be accounted for as it will be part of the bridge roadway.) | 5. | 2 TRESTLE ASSEMBLIES | 3 TRESTLE ASSEMBLIES | 4 TRESTLE ASSEMBLIES |
| | 5a | -15' | -30' | -45' |
| | 5b. | = 75' | = 60' | = |
| 6. Divide the value obtained in step 5b by 2 to determine the lengths of the two end span H-frames. | 6a. | ÷ 2 | ÷ 2 | ÷ 2 |
| NOTES: 1. If the value obtained in step 6b is greater than 45'0", You MUST return to step 5. Enter the next column, and repeat the design sequence. 2. You are not limited to adding only four trestle assemblies as may be implied by step 5. Only four are shown due to space limitations on this form. 3. When the value obtained in step 6b is less than or equal to 45'0", proceed to step 7. | 6b. | = 37.5' | = 30' | = |
| 7. Round UP the value obtained in step 6b to the next highest standard H-frame configuration from Table 7-26 (page 7-21). | 7. | ø 38'4" | ø 30' | ø |
| 8. Determine the D/R ratio required and corresponding MLC for the standard configuration obtained in step 7 from Table 7-26. (Remember: The 22 pieces of decking is the maximum which may be used with a trestle.) | 8a. | D/R = | D/R = 22/16 | D/R = |
| NOTES: 1. This must meet or exceed the MLC requirements as stated in step 1 and is always based on a NORMAL CROSSING unless otherwise directed by the Tactical Commander. 2. If the MLC requirement cannot be met or exceeded, you MUST return to step 5, enter the next column, and repeat the design sequence. Add as many trestle assemblies as needed. | 8b. | MLC = | MLC = 60/60 | MLC = |

9. Final bridge design:

| | | |
|---|---|---|
| a. H-frame end span configuration (from step 7). | 9a. | 30' |
| b. DR ratio (from step 8a). | 9b. | D/R = 22/16 |
| c. MLC of bridge (from step 8b; however, this value can NEVER exceed MLC 60 because this is the capacity of the trestle). | 9c. | MLC = 60/60 |
| d. Class 60 trestle assemblies required (from step 5). | 9d. | 3 |

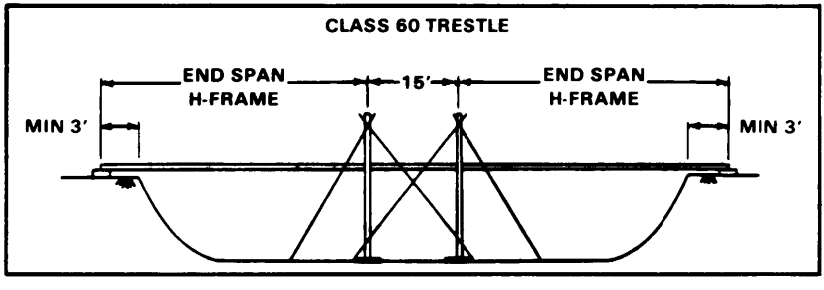



Figure 7-7. Two trestle assemblies

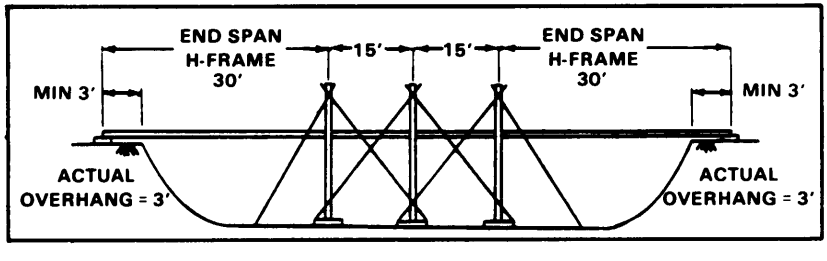



Figure 7-8. Three trestle assemblies

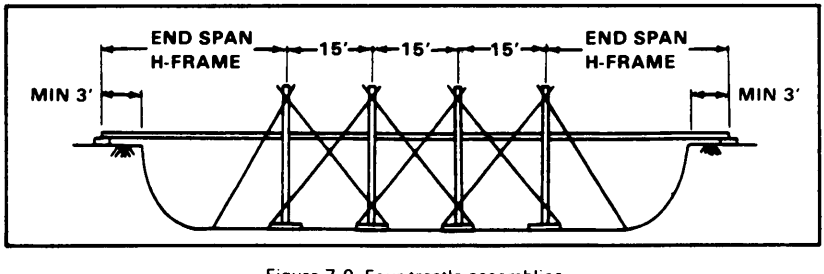



Figure 7-9. Four trestle assemblies

## Class 100 Trestle Arrangement

M4T6 FIXED SPAN BRIDGE DESIGN
FOR SUPPORT WITH CLASS 100 TRESTLE ARRANGEMENT
(FOR CLASSES 61 TO 100) WITH EXAMPLE

| | | |
|---|---|---|
| 1. Classification of the bridge that needs to be built (obtained from the mission statement). | 1. | MLC 70/70 |
| 2. Gap as measured during reconnaissance. | 2. | 66' |
| 3. Safety setback for both the FS and NS is a constant of 3' for both prepared and unprepared abutments. | 3a. | FS: +3' |
| | 3b. | NS +3' |
| 4. Initial bridge length (add steps 2 + 3a + 3b). | 4. | = 72' |

| | | 1 TRESTLE ARRANGEMENT | 2 TRESTLE ARRANGEMENT | 3 TRESTLE ARRANGEMENT |
|---|---|---|---|---|
| 5. Initially, enter the "1 trestle arrangement" column. You WILL NOT have to subtract any distance from step 4 because the end spans rest on the center of the trestle. NOTE: One trestle arrangement consists of two trestle assemblies; two trestle arrangements consist of four trestle assemblies. | 5. | | | |
| | 5a. | -0'0" | -23'4" | -46'8" |
| | 5b. | = 72' | = 48'8" | = |
| 6. Divide the value obtained in step 5b by 2 to determine the lengths of the two end span H-frames. NOTES: 1. If the value obtained in step 6b is greater than 30'0", you MUST return to step 5, enter the next column, and repeat the design sequence. 2. You are not limited to adding only three trestle arrangements as may be implied by step 5. Only three trestle arrangements are shown due to space limitations on this form. 3. When the value obtained in step 6b is less than or equal to 30'0", proceed to step 7. | 6a. | ÷ 2 | ÷ 2 | ÷ 2 |
| | 6b. | = 36' | = 24'4" | = |
| 7. Round UP the value obtained in step 6b to the next highest standard H-frame configuration from Table 7-26 (page 7-21). | 7. | ~~36~~ | ~~36~~ 30 | ~~36~~ |
| 8. Determine the D/R ratio required and corresponding MLC for the standard configuration obtained in step 7 from Table 7-26 (page 7-21). (Remember: The 22 pieces of decking is the maximum which may be used with a trestle.) NOTES: 1. This MUST meet or exceed the MLC requirements as stated in step 1 and is always based on a NORMAL CROSSING unless otherwise directed by the tactical commander. 2. If the MLC requirement cannot be met or exceeded, you MUST return to step 5, enter the next column, and repeat the design sequence. Add as many trestle arrangements as needed. | 8a. | D/R = | D/R = 22/16 | D/R = |
| | 8b. | MLC = | MLC = 90/70 | MLC= |

9. Final bridge design:

| | | |
|---|---|---|
| a. H-frame end span configuration (from step 7). | 9a. | 30' |
| b. H-frame end span D/R ratio (from step 8a). | 9b. | D/R = 22/16 |
| c. Number of trestle arrangement(s) required (from step 5). | 9c. | 2 |

d. Bridge length(s) between trestle arrangement(s). 9d. One 23'4" span

NOTES: 1. For one trestle arrangement, enter NA.
2. For two trestle arrangements, enter one 23'4" span.
3. For three trestle arrangements, enter two 23'4" spans.
4. For four or more trestle arrangements, the number of 23'4" spans that are required will be equal to the number of trestle arrangements minus one.

e. The MLC of bridge length(s) between trestle arrangement(s). 9e. MLC 100/100

NOTES: 1. For one trestle arrangement, enter NA.
2. For two or more trestle arrangements, use Table 7-26 (page 7-21) to obtain the MLC. Use the same D/R as shown under step 9b.

f. The MLC of trestle(s) (constant of 100). 9f. MLC 100/100

g. The MLC of end spans (from step 8b). 9g. MLC 90/70

h. The MLC of entire bridge (compare the values of steps 9e, 9f, and 9g; choose the smallest). 9h. MLC 90/70

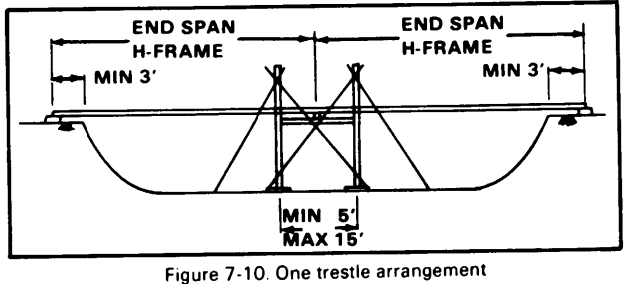



Figure 7-10. One trestle arrangement

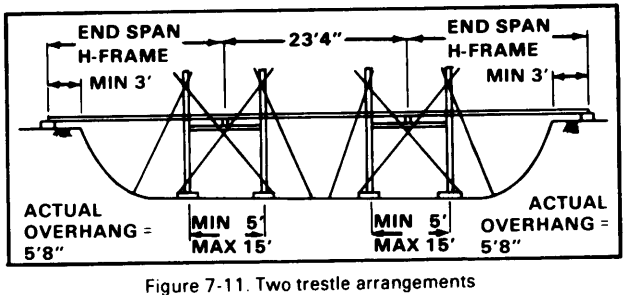



Figure 7-11. Two trestle arrangements

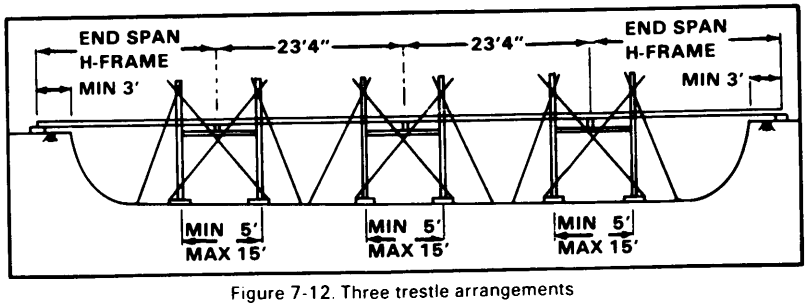



Figure 7-12. Three trestle arrangements

# MEDIUM GIRDER BRIDGE (MGB)

For more detailed information pertaining to component descriptions, construction, palletizing, and maintenance procedures, refer to TM 5-5420-212-12 for the MGB, and to TM 5-5420-212-12-1 for the link reinforcement set (LRS).

## Abbreviations

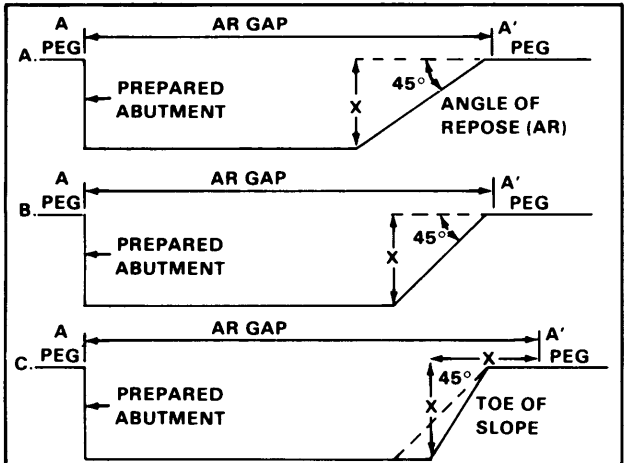
| | |
|---|---|
| **A** | indicates edge of gap, far bank |
| **A'** | indicates edge of gap, near bank |
| **AA** | anchor assembly |
| **AA(L)** | long link of anchor assembly |
| **AA(S)** | short link of anchor assembly |
| **AF** | antiflutter tackle |
| **AR** | Angle of repose which is marked on site with A (far bank) and A' (near bank) pegs. |
| **AR Gap** | The distance from the edge of firm ground (A') on the near bank to the edge of firm ground (A) on the far bank. |
| **BES** | bridge erection set |
| **Boom Marker** | Carrying bar (painted orange) which marks the position of the next booming/launching point. |
| **BP** | building pedestal (SS only), baseplate (SS and DS) |
| **BSB** | bank seat beam |
| **C** | Distance of water below line joining FRB and F at distance W from FRB (negative). Fine for up to 2E+12. For 13 to 22 bays, a CRB is required. |
| **CG Marker** | Carrying bar (painted blue) which marks the center of gravity of the bridge during construction. |
| **CRB** | Capsill roller beam MUST be used for 2E+13 through 2E+22 bays DS bridges with or without LRS. |
| **D** | Deflection of bridge during launch in relation to line joining FRB and F pegs. |
| **DS** | double story bridge construction |
| **DU** | deck unit |
| **E** | end of bridge |
| **F** | Final position of the far end of the bridge as marked with the F peg. |
| **F'** | Final position of the near end of the bridge as marked with the F' peg. |
| **FRB** | front roller beam |
| **G** | distance between 0 peg and baseline |
| **H** | far bank height at F peg, relative to the baseline |
| **Ht** | height |
| **L** | length of bridge |
| **LLN** | light launching nose |
| **LNCG** | launching nose cross girder |
| **LNH** | launching nose heavy |
| **LR** | Landing roller. Used by itself for 4 through 8 bays SS. Used in LRP for all other bridge lengths. |
| **LRD** | Long ramp and deck pallet. The last pallet to be used on a bridge site should be loaded on the push vehicle to maintain a proper counterweight. |
| **LRP** | Landing roller pedestal (MK I for 2E+1 through 2E+12 bays DS-MK 2 for 2E+13 through 2E+22 bays DS with or without LRS). |
| **LRS** | link reinforcing set |
| **LT** | light tackle |
| **LZ** | landing zone |
| **MLC** | military load class |
| **N** | nose tip height above baseline |
| ***N1** | launching nose heavy one story high |
| ****N2** | launching nose heavy two stories high |

| | |
|---|---|
| **O** | Distance "R" from RB (single story), FRB (double story), and CRB (double story with or without LRS) as marked with the O peg. |
| **PT** | post tensioning assembly |
| **R** | Maximum distance to the rear of bridge during construction (excluding push bar and vehicle). |
| **RB** | roller beam |
| **RRB** | rear roller beam |
| **SS** | single story bridge construction |
| **T** | Height of home bank end of bridge in relation to baseline. |
| **V** | For delaunching purposes, the distance from the FRB or CRB to the LRP for DS bridges requiring a launching nose. |
| **W** | Distance of end taper panel from FRB for maximum deflection. |
| **WL** | waterline |
| **1LL** | one long link |
| **1SL** | one short link |
| ***6N1,7N1, and 8N1** | Types of single story nose construction. The first number shows the number of heavy nose sections used. The N1 means single nose. |
| ****6N1 + 3N2** | Type of double story nose construction. The 6N1 is explained above. The 3N2 means three heavy nose sections used in second story. The N2 means nose double story. |
| **2 + 3 + or 8 through 10** | Describes the number of bays to be added. The 2+3+ means add second and third bays and the 8 through 10 means add bays 8 through 10. |
| **Boom to** | Movement of bridge until the panel point given is over the RB (for SS) or RRB (for DS). |
| **Launch to** | Movement of bridge until the panel point given is over the RB, FRB, or CRB. |
| **3D, 8D, 20D, 27D+6C, and 37D + 6C** | Counterweight codes giving the number of deck units and curbs required. |
| **(4p0), (2p4), and (Bp3)** | Examples of the way that the center of gravity is shown. |

## Design

### Measure

Measure the angle of repose (AR) gap. See Figure 7-13 Select a bridge centerline Measure a distance from the firm ground on the home bank to the firm ground on the far bank.




NOTES: 1. If actual slope of bank does not exceed 45° from the horizontal, place A, A' peg as shown in A or B.

2. If actual slope of bank does exceed 45° from the horizontal, place A, A' peg a distance equal to the height of the bank which is measured from the toe of slope. This is illustrated in C by the distance X.

3. Gaps above are shown with one prepared and one unprepared abutment. Actual sites may be any combination of examples shown.

Figure 7-13. Measuring AR gap

### Select

Select a bridge from Table 7-27 to meet the AR gap and MLC required. Using the bridge selected, go to the appropriater page: single story, page 7-33; double story 1 - 12 bays, page 7-37; double story 13-22 bays without LRS, page 7-41; double story 13 - 22 bays with LRS, page 7-45.

**Table 7-27. Bridge selection table**

| SS BRIDGES 4 - 12 BAYS TABLE A | | DS 1 - 12 BAYS TABLE B | | DS 13 - 22 BAYS TABLE C | | | |
|---|---|---|---|---|---|---|---|
| AR gap M | MLC | AR gap M | MLC | AR GAP M wo/LRS | MLC | AR GAP M w/LRS | MLC |
| 3.7 - 6.1 | 60 | 6.7 - 9.0 | 60 | 28.6 - 30.9 | 50 | 28.6 - 31.4 | 60 |
| 5.6 - 8.0 | 60 | 8.5 - 10.8 | 60 | 30.5 - 32.8 | 50 | 30.5 - 33.3 | 60 |
| 7.4 - 9.8 | 40 | 10.3 - 12.6 | 60 | 32.3 - 34.6 | 40 | 32.3 - 34.7 | 60 |
| 9.2 - 11.6 | 30 | 12.2 - 14.5 | 60 | 34.1 - 36.4 | 40 | 34.1 - 36.9 | 60 |
| 11.0 - 13.4 | 30 | 14.0 - 16.3 | 60 | 35.9 - 38.2 | 30 | 35.9 - 38.7 | 60 |
| 12.9 - 15.3 | 24 | 15.8 - 18.1 | 60 | 37.8 - 40.1 | 30 | 37.8 - 40.6 | 60 |
| 14.7 - 17.1 | 20 | 17.7 - 20.0 | 60 | 39.6 - 41.9 | 24 | 39.6 - 42.4 | 60 |
| 16.5 - 18.9 | 16 | 19.5 - 21.8 | 60 | 41.4 - 43.7 | 24 | 41.4 - 44.2 | 60 |
| 18.4 - 20.8 | 16 | 21.3 - 23.6 | 60 | 43.3 - 45.6 | 20 | 43.3 - 45.6 | 60 |
| | | 23.1 - 25.4 | 60 | 45.1 - 47.4 | 16 | 45.1 - 46.5 | 60 |
| | | 25.0 - 27.3 | 60 | | | | |
| | | 26.8 - 29.1 | 60 | | | | |

Single story MGB design - 4 to 12 bays long

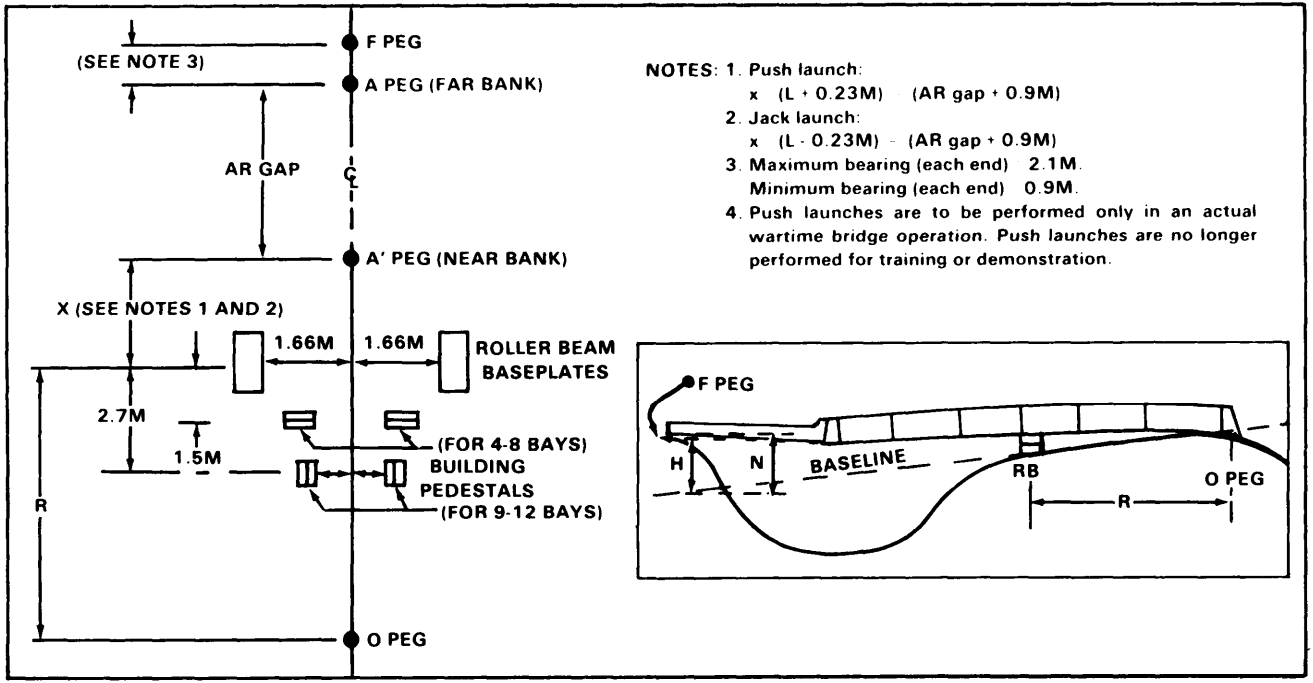



Figure 7-14. Single story MGB site layout (4 through 12 bays)

**MGB DESIGN PROFORMA SS 4 TO 12 BAYS**
**(All Measurements are in Meters)**

Grid _____ Recon Officer _____ Map Ref _____

Unit _____ MLC _____

1. Measure AR gap A to A' _____

NOTE Use Table 1 or 2 to obtain the answers to the following

2. Select bridge _____

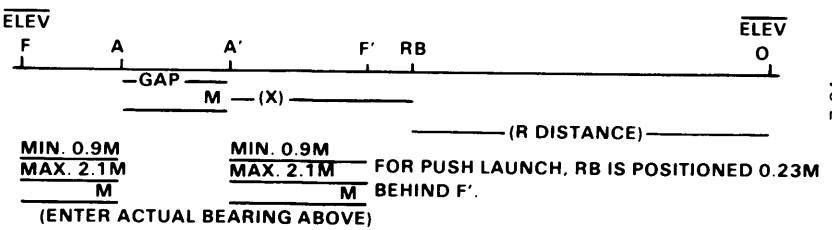
3. Bridge length _____

4. R distance _____

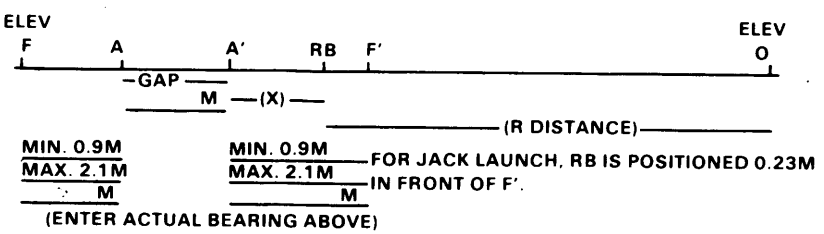
5. Nose construction _____

6. Key construction points, dimensions, and elevations.
Calculate the distance from the RB to A' peg (X), where:

a. Push launch. X = (L + 0.23M) - (AR gap + 0.9M)




b. Jack launch. X = (L - 0.23M) - (AR gap + 0.9M)




c. Check bearing. Bearing FB + AR gap + bearing HB = L

7. Slope check. Ensure that the difference in elevation between the F' and the F pegs does not exceed 1/10th of the total bridge length. If it does, you are either going to have to crib up, undertake a major construction project, or find another centerline.

**TABLE 1**

| BRIDGES 4-8 BAYS SS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SITE DIMENSIONS | | | | | | LAUNCH DESIGN | | | |
| AR Gap (a) | L (b) | Bays (c) | MLC (d) | Nose (e) | R Dist (f) | RB BP Only (g) | RB BP+DU Only (h) | N BP Only (i) | N BP+DU Only (j) |
| 3.7-6.1 | 7.9 | 4 | 60 | LLN ONLY | 5.8 | 0.43 | 0.60 | 1.30 | 1.75 |
| 5.6-8.0 | 9.8 | 5 | 60 | | 6.7 | | | 1.14 | 1.68 |
| 7.4-9.8 | 11.6 | 6 | 40 | | 7.6 | | | 1.07 | 1.60 |
| 9.2-11.6 | 13.4 | 7 | 30 | | 9.5 | | | 0.76 | 0.91 |
| 11.0-13.4 | 15.2 | 8 | 30 | | 11.3 | | | 0.38 | 0.84 |

**TABLE 2**

| BRIDGES 9-12 BAYS SS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SITE DIMENSIONS | | | | | | Dimension N above line through ground at RB and O when rear BSB is on ground. The RB is on BP or BP and DU, and LNCG is on 4, 2, or 1. | | | | | |
| | | | | | | LNCG SETTINGS | | | | | |
| | | | | | | 4 | | 2 | | 1 | |
| AR Gap (a) | L (b) | Bays (c) | MLC (d) | Nose (e) | R Dist (f) | BP Only (g) | BP+ DU (h) | BP Only (i) | BP+ DU (j) | BP Only (k) | BP+ DU (l) |
| 12.9-15.3 | 17.1 | 9 | 24 | 5N1 | 10.4 | -0.76 | -0.08 | 0.61 | 1.14 | 1.83 | 2.36 |
| 14.7-17.1 | 18.9 | 10 | 20 | | 12.2 | -0.99 | -0.61 | 0.38 | 0.76 | 1.60 | 1.98 |
| 16.5-18.9 | 20.7 | 11 | 16 | 6N1 | 12.2 | -1.37 | -1.07 | 0.15 | 0.48 | 1.83 | 2.44 |
| 18.4-20.8 | 22.6 | 12 | 16 | | 14.0 | -2.13 | -1.60 | -0.46 | 0.08 | 1.07 | 1.60 |

NOTES:
1. An extra 75mm of clearance can be obtained by lifting on the nose to take out the pin sag. Where levels are estimated this should not be taken into account during the design but left to compensate for any inaccuracies in calculating the value of H (for bridges 4 to 8 bays).
2. An extra 0.6M of clearance can be obtained by lifting on the nose to take out pin sag (for bridges 9 to 12 bays).
3. Any additional packing under the RB will increase the vertical interval N by three times the thickness of the packing; such as, if the packing is 75mm thick, N will be increased by 225mm.
4. The table incorporates an allowance to ensure that the nose clears the LR when it is positioned 230mm in front of point F.

8. Calculate H H = HtF + $\frac{[HtO \times (L \pm 0.23)]}{R \text{ distance}}$ +0.23 if push launch; -0.23 if jack launch

9. Launch design:

| 4 to 8 Bays (Table 1) | 9 to 12 Bays (Table 2) |
|---|---|
| Choose a packing where N > H (From columns i or j) | Choose an LNCG setting where N > H (From columns g, h, i, j, k, or l) |
| Packing _____ (From columns g or h) | LNCG Setting _____ Packing _____ |

10. Loads required. From Table 3, determine the truck and trailer loads required for the bridge.

| TABLE 3 | MGB PALLETS SS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pallet Type | Number of Bays | | | | | | | | |
| | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | Erection | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Bridge | 2 | 2 | 3 | 3 | 4 | 4 | 5 | 5 | 5 |
| | Total | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 6 |

NOTE: More vehicles are required to transport personnel. Erection pallets may only be partial depending on bridge being constructed.

11. Construction times and manpower requirements. From Table 4, extract the following information:

a. Construction time _____

b. Manpower requirements _____

| TABLE 4 | WORKING PARTIES AND BUILDING TIMES ON GOOD SITES (FIRM DRY GROUND) | | | |
|---|---|---|---|---|
| | | Single Story | | |
| | | 5 Bays 9.8M MLC 60 | 8 Bays 15.2M MLC 30 | 12 Bays 22.6M MLC 16 |
| | (a) | (b) | (c) | (d) |
| | Working Party | 1 + 8 | 1 + 16 | 1 + 16 |
| | Time by Day (hours) | 1/2 | 3/4 | 1 |
| | Time by Night (hours) | 3/4 | 1 | 1 1/4 |

12. Final design.

a. Bays _____

b. LNCG setting _____

c. Packing required _____

d. Bearing: HB _____ FB _____

e. Truck and trailer loads _____

f. Manpower required _____

g. Time to construct _____

Double story MGB (2E+1 through 2E+12)

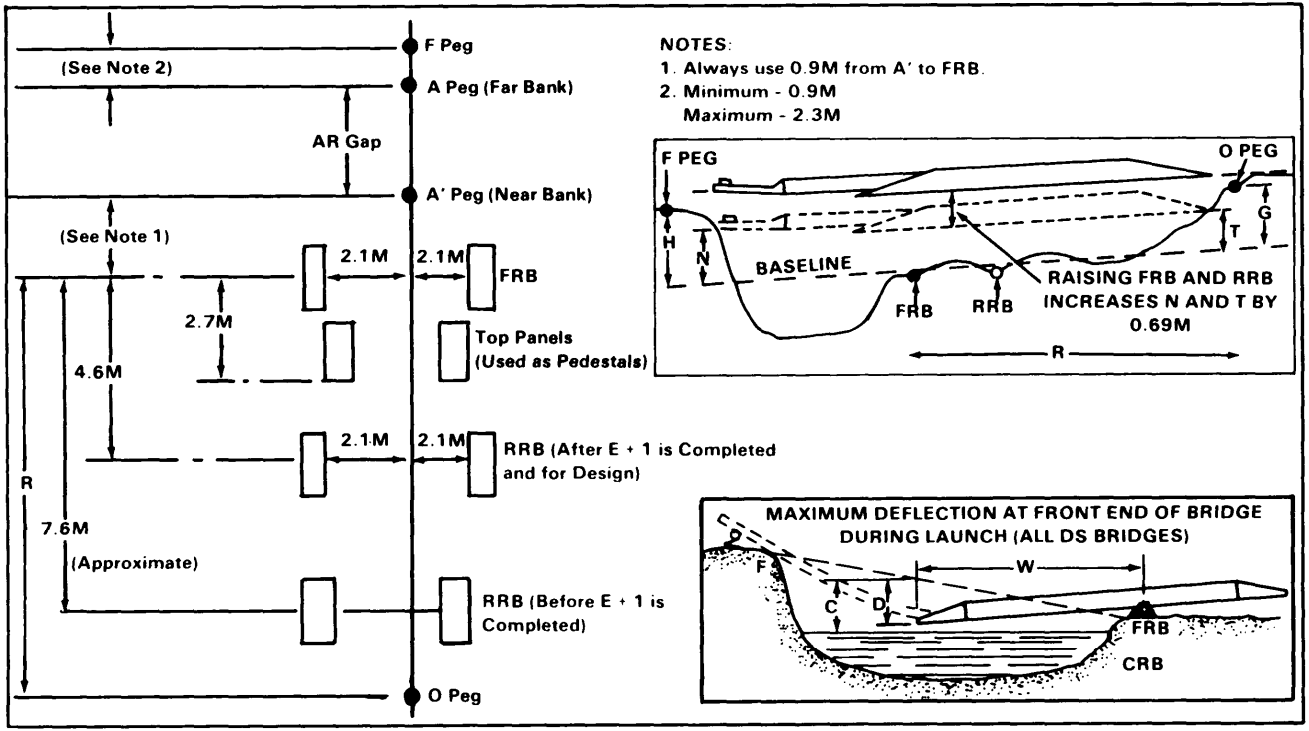



Figure 7-15. Double story MGB site layout (2E+1 through 2E+12 bays)

## MGB DESIGN PROFORMA DS 2E+1 THROUGH 2E+12 BAYS

Grid _____ Recon Officer _____ Map Ref _____

Unit _____ MLC _____

1. Measure AR gap A to A' _____

NOTE: Use Table 1 to obtain the answers to the following:

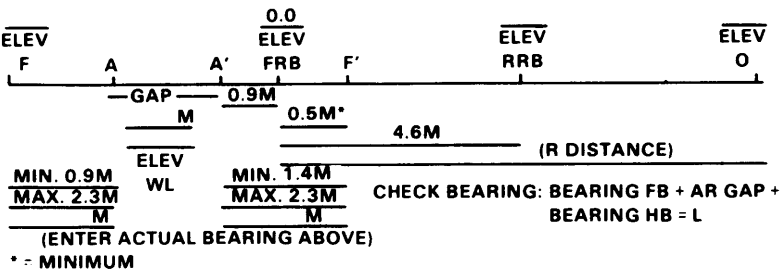
2. Select bridge 2E + bays

3. Bridge length _____

4. R distance _____

5. Nose construction _____

6. Key construction points, dimensions, and elevations:




7-38

7. Slope check. Ensure that the difference in elevation between the F' and F peg does not exceed 1/10th of the total bridge length. If it does, you are either going to have to crib up, undertake a major construction project, or find another centerline.

8. Calculate H, G, and C:

$$H = HtF + \frac{HtRRB \times (L - 0.5)}{4.6}$$

$$G = HtO - \frac{HtRRB \times R\ dist}{4.6}$$

$$C = HtWL - \frac{HtF \times W\ dist}{(L - 0.5)}$$

9. Rule 1. (If both bank heights > 0.6M, go to Rule 2.)

Choose a LNCG setting that ensures depth of C > depth of D.

LNCG settings permitted ____ ____ ____

10. Rule 2. Use a LNCG setting to give N > H and T > G.

Choose a LNCG setting so that N > H.

LNCG setting chosen _____

NOTE: Setting chosen cannot be lower than that chosen in Rule 1.

If N ▷ H and/or T ▷ G, go to Rule 3.

11. Rule 3. Raise the FRB and RRB by 0.69M.

$N_{Rule\ 3} = N_{Rule\ 2} + 0.69M$ N = _____

Check T > G — Yes/No (Column p) T = _____

If yes, design is all right.

If $N_{Rule3}$ H ▷ go to Rule 4A.

If $T_{Rule3}$ G ▷ go to Rule 4B.

**TABLE 1**

**DS MGB DESIGN 2E + 1 THROUGH 2E + 12 BAYS**
**(all measurements are in meters)**

| Site Dimensions | | | | | | RULE 1 D for Given LNCG Setting with FRB in Lowest Position | | | | | Launch Design: RULE 2 Nose lift N, Using Various LNCG Settings and FRB in Lowest Position | | | | Other Methods of Adjusting N and T: RULE 3 Raise FRB and RRB by 0.69M | | RULE 4A Lowering to Increase N | 4B Lowering FRB to Increase T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AR Gap (a) | Brg Lgth (b) | 2E + # of Bays (c) | MLC (d) | Nose Const Note 1 (e) | R Dist (f) | W Dist (g) | Hole #6 Note 2 (h) | Hole #4 Note 2 (i) | Hole #2 Note 2 (j) | Tall Lift T (k) | Hole #6 Note 2 (l) | Hole #4 Note 2 (m) | Hole #2 Note 2 (n) | N (o) | T (p) | N (q) | T (r) |
| 6.7-9.0 | 11.3 | 1 | All DS MGBs are MLC 60 | 2N1 | 10.0 | — | — | — | — | | 1.02 | 1.48 | 2.04 | $N_{Rule\ 3} = N_{Rule\ 2} + 0.69M$ | 1.24 | 1.75 (1.24-G) | $0.2\ (N_{Rule\ 3} - H)$ |
| 8.5-10.8 | 13.1 | 2 | | 3N1 | 11.9 | — | — | — | — | | 0.89 | 1.53 | 2.30 | | | | |
| 10.3-12.6 | 14.9 | 3 | | | 12.2 | — | — | — | — | 0.55 | 0.86 | 1.50 | 2.28 | | | | |
| 12.2-14.5 | 16.8 | 4 | | | 13.1 | — | — | — | — | | 0.81 | 1.45 | 2.23 | | | | |
| 14.0-16.3 | 18.6 | 5 | | 4N1 | 14.9 | — | — | — | — | | 0.70 | 1.52 | 2.51 | | 1.21 | 1.75 (1.21-G) | |
| 15.8-18.1 | 20.4 | 6 | | | 14.9 | — | — | — | — | | 0.65 | 1.48 | 2.47 | | | | |
| 17.7-20.0 | 22.3 | 7 | | | 15.8 | 13.1 | 0.70 | 0.31 | -0.09 | 0.52 | 0.53 | 1.36 | 2.36 | | | | |
| 19.5-21.8 | 24.1 | 8 | | 5N1 | 16.8 | 15.0 | 0.67 | 0.25 | -0.20 | | 0.49 | 1.48 | 2.69 | | 1.15 | 1.75 (1.15-G) | |
| 21.3-23.6 | 25.9 | 9 | | | 17.7 | 16.5 | 0.64 | 0.21 | -0.30 | 0.46 | 0.33 | 1.35 | 2.55 | | | | |
| 23.1-25.4 | 27.7 | 10 | | | 19.5 | 17.6 | 0.60 | 0.12 | -0.40 | | 0.25 | 1.28 | 2.49 | | | | |
| 25.0-27.3 | 29.6 | 11 | | 6N1 | 20.4 | 18.5 | 0.50 | 0.04 | -0.43 | 0.40 | 0.16 | 1.23 | 2.63 | | 1.09 | 1.75 (1.09-G) | |
| 26.8-29.1 | 31.4 | 12 | | | 21.6 | 19.2 | 0.46 | -0.06 | -0.58 | | -0.20 | 1.02 | 2.47 | | | | |

NOTES:1. Each nose includes a light nose complete.

2. Nose cross girder setting — 6, 4, and 2 is the position of the cross girder resting on the 6th, 4th, and 2d hole from the bottom of the LNCG post.

12. Rule 4A. Lower RRB.

$N = N_{Rule\ 3}$ + answer to Column q

Check N > H

13. Rule 4B. Lower FRB.

$T = T_{Rule\ 3}$ + answer to Column r

Check T > G

14. Loads required.

From Table 2, determine the truck and trailer loads required for the bridge.

TABLE 2

| MGB PALLETS DS | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pallet Type | Bays | | | | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Erection | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Bridge | 5 | 5 | 5 | 6 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 8 |
| Total | 6 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 8 | 9 | 9 | 9 |

NOTE: More vehicles are required to transport personnel.

15. Construction time and manpower requirements.

From Table 3, extract the following information:

a. Construction time _____

b. Manpower requirements _____

TABLE 3

| WORKING PARTIES AND BUILDING TIMES ON GOOD SITES | | | |
|---|---|---|---|
| | Double Story Single Span | | |
| | 4 Bays 16.8M MLC 60 | 8 Bays 24.1M MLC 60 | 12 Bays 31.4M MLC 60 |
| (a) | (b) | (c) | (d) |
| Working Party | 1 + 24 | 1 + 24 | 1 + 24 |
| Time by Day (hours) | ¾ | 1 | 1 ½ |
| Time by Night (hours) | 1 ¼ | 1 ½ | 2 |

NOTES: 1. All timings exclusive of work on approaches and so forth.
2. Add 20 percent for unskilled personnel.
3. Add 30 percent for adverse site conditions.

16. Final design.

a. 2E + _____ Bays

b. LNCG setting _____

c. FRB setting _____

d. RRB setting _____

e. Bearing: HB _____ FB _____

f. Truck and trailer loads _____

g. Manpower required _____

h. Time to construct _____

Double story (2E+13 through 2E+22) without LRS

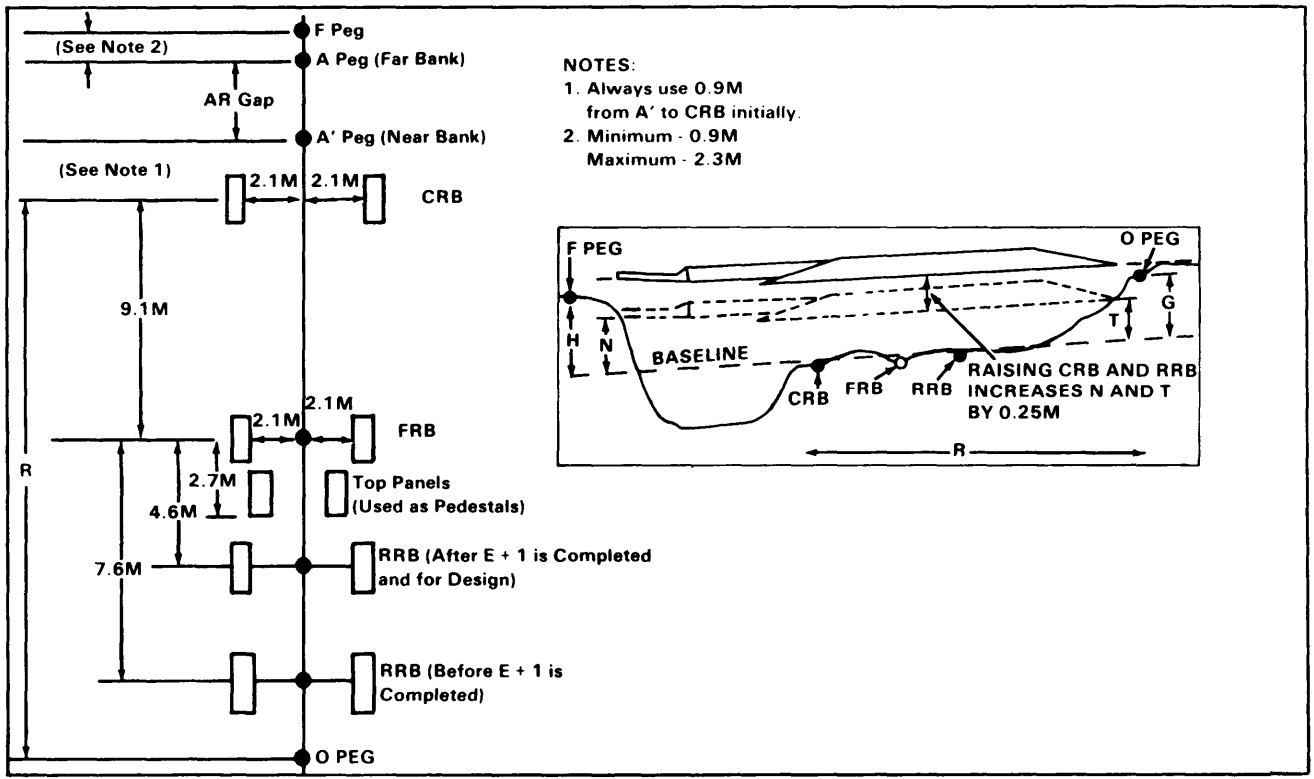



Figure 7-16. Double story MGB site layout (2E+13 through 2E+22 bays) without LRS

**MGB DESIGN PROFORMA DS 2E+ 13THROUGH 2E+22 BAYS**
**(Without LRS)**
**Where Water Level or Any Obstructions**
**are at Least 2.7M Below Bank Heights**

Grid _____ Recon Officer _____ Map Ref _____

Unit _____ MLC _____

1. Measure AR gap A to A' _____

NOTE: Use Table 1 to obtain the answers to the following:

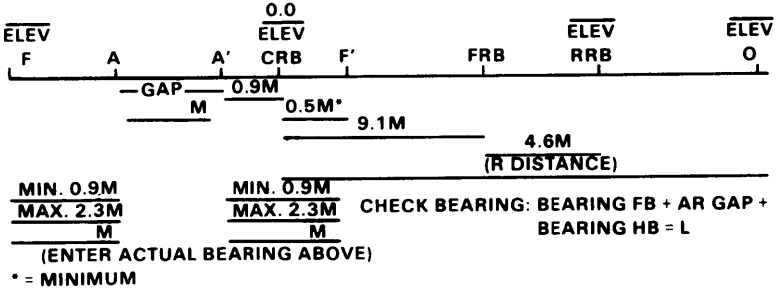
2. Select bridge 2E + Bays

3. Bridge length _____

4. R distance _____

5. Nose construction _____

6. Key construction points, dimensions, and elevations:




7. Slope check. Ensure that the difference in elevation between the F' and F peg does not exceed 1/10th of the total bridge length. If it does, you are either going to have to crib up, undertake a major construction project, or find another centerline.

8. Calculate H and G:

$$H = HtF + \frac{HtRRB \times (L - 0.5)}{13.7}$$

$$G = HtO - \frac{HtRRB \times R\ dist}{13.7}$$

9. Rule 1. Use a LNCG setting to give N > H and T > G.

Choose a LNCG setting so that N > H. LNCG setting chosen _____

Then check if T > G.

If N ≯ H and/or T ≯ G, then go to Rule 2.

10. Rule 2. Raise the CRB and RRB by 0.253M.

Check N > IH — Yes/ No (Column k)  Check T > G – Yes/No (Column l)

If yes, design is all right.

If N > H, go to Rule 3A.

If T > G, go to Rule 3B.

**TABLE 1**

**DS MGB 2E + 13 THROUGH 2E + 22 BAYS WITHOUT LRS WHERE WATER OR ANY OBSTRUCTIONS ARE AT LEAST 2.7M BELOW BANK HEIGHTS**

| Site Dimensions | | | | | | Launch Design | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | RULE 1 Nose Lift N with Nose Cross Girder at: | | | | Other Methods of Adjusting N and T | | | |
| | | | | | | | | | | RULE 2 Raise RRB and CRB by 0.25M | | RULE 3 Lowering RRB to Increase N | RULE 3B Lowering CRB to Increase T |
| AR Gap (a) | Brg Lgth (b) | 2E + # of Bays (c) | MLC (d) | Nose Const Note 1 (e) | R Dist (f) | Tail Lift T (g) | Hole #6 Note 2 (h) | Hole #4 Note 2 (i) | Hole #2 Note 2 (j) | N (k) | T (l) | N (m) | T (n) |
| 28.6-30.9 | 33.2 | 13 | 50 | 6N1 | 27.4 | 0.40 | -0.07 | 1.49 | 2.68 | 2.93 | 0.65 | 1.9 (0.82-G) | 0.2 (2.93-H) |
| 30.5-32.8 | 35.1 | 14 | | | 28.7 | 0.37 | -0.38 | 1.00 | 2.65 | 2.90 | 0.62 | 1.9 (0.79-G) | 0.2 (2.90-H) |
| 32.3-34.6 | 36.9 | 15 | 40 | 7N1 | 28.7 | 0.34 | -0.49 | 0.90 | 2.55 | 2.80 | 0.59 | 1.9 (0.76-G) | 0.2 (2.80-H) |
| 34.1-36.4 | 38.7 | 16 | | | 29.6 | 0.30 | -0.61 | 0.79 | 2.43 | 2.68 | 0.55 | 1.9 (0.72-G) | 0.2 (2.68-H) |
| 35.9-38.2 | 40.5 | 17 | 30 | 8N1 | 29.3 | 0.27 | -0.15 | 0.75 | 2.69 | 2.94 | 0.52 | 1.9 (0.69-G) | 0.2 (2.94-H) |
| 37 8-41 9 | 42.4 | 18 | | | 29.3 | 0.24 | -1.33 | 0.54 | 2.54 | 2.79 | 0.49 | 1.9 (0.66-G) | 0.2 (2.79-H) |
| 39.6-40.1 | 44.2 | 19 | 24 | 6N1+3N2 | 34.8 | 0.21 | -2.04 | -0.19 | 1.72 | 1.97 | 0.46 | 1.9 (0.63-G) | 0.2 (1.97-H) |
| 41.4-43.7 | 46.0 | 20 | | | 38.4 | 0.21 | -1.93 | -0.31 | 1.61 | 1.86 | 0.46 | 1.9 (0.63-G) | 0.2 (1.86-H) |
| 43 3-44.6 | 47.9 | 21 | 20 | | 38.4 | 0.18 | -2.65 | -0.52 | 1.17 | 1.42 | 0.43 | 1.9 (0.60-G) | 0.2 (1.42-H) |
| 45.1-47.4 | 49.7 | 22 | 16 | | 40.1 | 0.15 | -2.58 | -0.68 | 1.04 | 1.29 | 0.40 | 1.9 (0.57-G) | 0.2 (1.29-H) |

NOTES: 1. Each nose includes a light nose complete

2. Nose cross girder setting – 6, 4, and 2 is the position of the cross girder resting on the 6th, 4th, and 2d hole from the bottom of the LNCG post.

11. Rule 3A. Lower RRB.

$N = N_{Rule\ 2}$ + answer to Column m

Check N > H

12. Rule 3B. Lower CRB.

$T = T_{Rule\ 2}$ + answer to Column n

Check T > G

13. Loads required.

From Table 2, determine the truck and trailer loads required for the bridge.

TABLE 2

| MGB PALLETS DS wo/LRS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Pallet Type | Bays | | | | | | | | | |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| Erection | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Bridge | 9 | 9 | 9 | 10 | 10 | 10 | 11 | 11 | 11 | 12 |
| Total | 10 | 10 | 10 | 11 | 11 | 11 | 12 | 12 | 12 | 13 |

NOTE: More vehicles are required to transport personnel.

14. Construction time and manpower requirements.

From Table 3, extract the following information:

a. Construction time _____

b. Manpower requirements _____

15. Final design.

a. 2E + _____ Bays

b. LNCG setting _____

c. CRB setting _____

d. RRB setting _____

e. Bearing

HB _____

FB _____

f. Truck and trailer loads _____

g. Manpower required _____

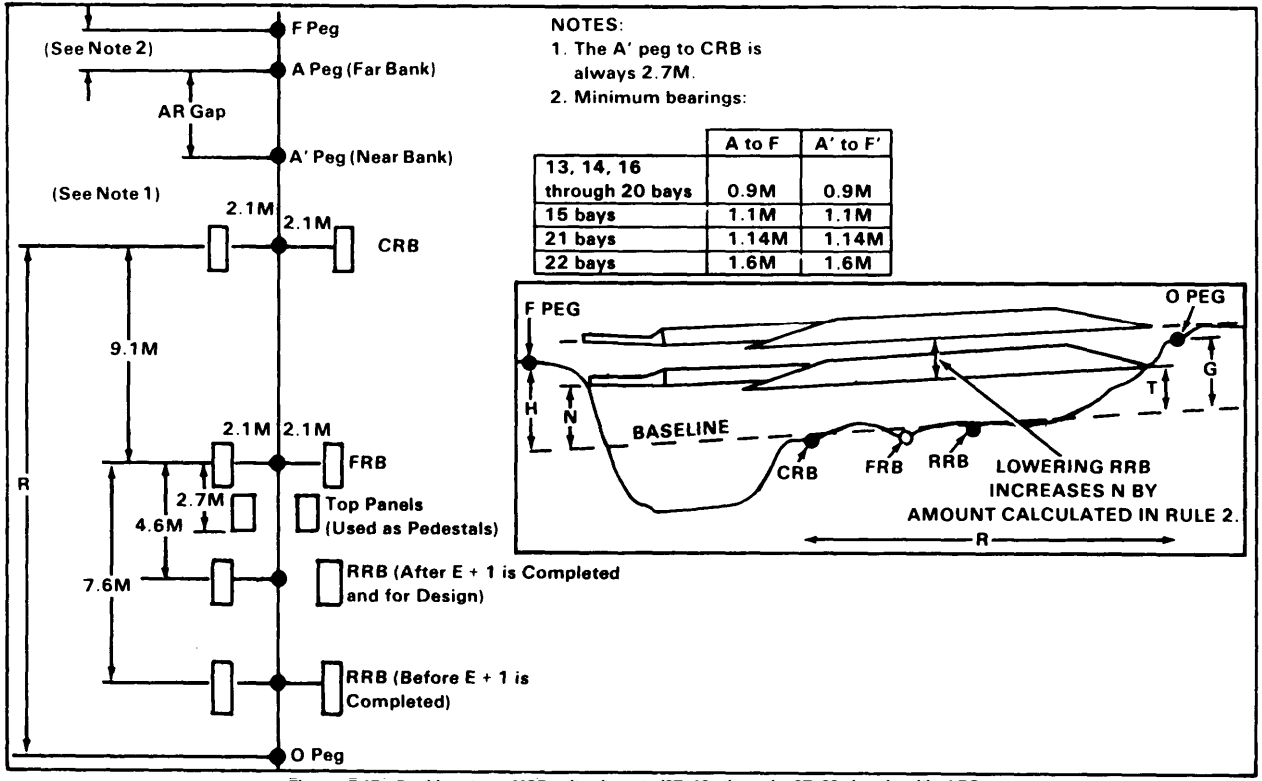
h. Time to construct _____

TABLE 3

| WORKING PARTIES AND BUILDING TIMES ON GOOD SITES | | | |
|---|---|---|---|
| | Double Story Single Span 13-22 Bays wo/LRS | | |
| (a) | 13 Bay 33.2M MLC 50 (b) | 18 Bay 42.4M MLC 30 (c) | 22 Bay 49.7M MLC 60 (d) |
| Working Party | 1 + 24 | 1 + 24 | 1 + 24 |
| Time by Day (hours) | 1 ½ | 1 ¾ | 2 |
| Time by Night (hours) | 2 | 2 ¾ | 3 |

NOTES: 1. All timings exclusive of work on approaches and so forth.
2. Add 20 percent for unskilled personnel.
3. Add 30 percent for adverse site conditions.

Double story (2E+13 through 2E+22) with LRS




| | A to F | A' to F' |
|---|---|---|
| 13, 14, 16 through 20 bays | 0.9M | 0.9M |
| 15 bays | 1.1M | 1.1M |
| 21 bays | 1.14M | 1.14M |
| 22 bays | 1.6M | 1.6M |

Figure 7-17. Double story MGB site layout (2E+13 through 2E+22 bays) with LRS

**MGB DESIGN PROFORMA DS 2E + 13 THROUGH 2E + 22 BAYS**
**(With LRS)**
**Where Water Level or Any Obstructions**
**are at Least 3.7M Below Bank Heights**

Grid _____ Recon Officer _____ Map Ref _____

Unit _____ MLC _____

1. Measure AR gap A to A' _____

NOTE: Use Table 1 to obtain the answers to the following:

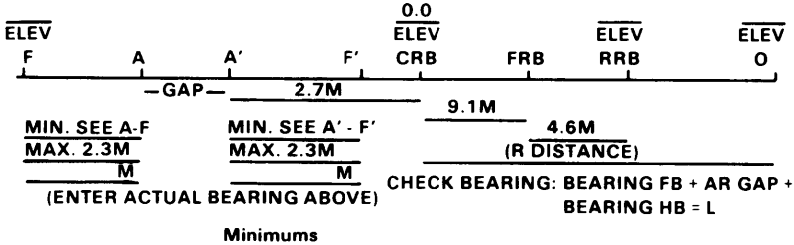
2. Select bridge 2E + Bays

3. Bridge length _____

4. R distance _____

5. Nose construction _____

6. Key construction points, dimensions, and elevations:




**Minimums**

| | A to F | A' to F' |
|---|---|---|
| 13, 14, 16 through 20 bays | 0.9M | 0.9M |
| 15 bays | 1.1M | 1.1M |
| 21 bays | 1.14M | 1.14M |
| 22 bays | 1.6M | 1.6M |

7. Slope check. Ensure that the difference in elevation between the F' and F peg does not exceed 1/20th of the total bridge length. If it does, you are either going to have to crib up, undertake a major construction project, or find another centerline.

8. Calculate H and G:

$$H = HtF + \frac{HtRRB \times (L - 0.5)}{13.7}$$

$$G = HtO - \frac{HtRRB \times R\ dist}{13.7}$$

9. Rule 1. Use a LNCG setting to give N > H and T > G.

Choose a LNCG setting so that N > H. LNCG setting chosen _____

If N ≯ H, then go to Rule 2.

If T ≯ G, choose another site or prepare to dig out under HB end of bridge prior to launch.

10. Rule 2. Lower RRB

$N = N_{Rule\ 1}$ + answer to Column k

Check N > H

TABLE 1

DS MGB 2E + 13 THROUGH 2E + 22 BAYS WITH LRS WHERE WATER OR ANY OBSTRUCTIONS ARE AT LEAST 3.7M BELOW BANK HEIGHTS

| Site Dimensions | | | | | | Launch Design | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | RULE 1 Nose Lift N with Nose Cross Girder at: | | | | RULE 2 Lowering RRB to Increase N |
| AR Gap (a) | Brg Lgth (b) | 2E + # of Bays (c) | MLC (d) | Nose Const Note 1 (e) | R Dist (f) | Tail Lift T (g) | Hole #6 Note 2 (h) | Hole #4 Note 2 (i) | Hole #2 Note 2 (j) | N (k) |
| 28.6-31.4 | 33.2 | 13 | All MLC 60 | 7N1 | 27.4 | -0.40 | 0.48 | 1.87 | 3.52 | 1.9 (0.82-G) |
| 30.5-33.3 | 35.1 | 14 | | | 28.7 | -0.37 | 0.31 | 1.72 | 3.35 | 1.9 (0.79-G) |
| 32.3-34.7 | 36.9 | 15 | | | 28.7 | -0.34 | 0.25 | 1.64 | 3.29 | 1.9 (0.76-G) |
| 34.1-36.9 | 38.7 | 16 | | 8N1 | 29.6 | -0.30 | -0.82 | 1.27 | 3.25 | 1.9 (0.72-G) |
| 35.9-38.7 | 40.6 | 17 | | | 29.3 | -0.27 | -0.77 | 1.12 | 3.10 | 1.9 (0.69-G) |
| 37.8-40.6 | 42.4 | 18 | | 6N1+3N2 | 29.3 | -0.21 | -1.06 | 0.80 | 2.71 | 1.9 (0.66-G) |
| 39.8-42.4 | 44.2 | 19 | | | 34.8 | -0.21 | -1.46 | 0.40 | 2.32 | 1.9 (0.63-G) |
| 41.4-44.2 | 46.0 | 20 | | | 38.4 | -0.21 | -1.75 | 0.11 | 2.03 | 1.9 (0.63-G) |
| 43.3-45.6 | 47.9 | 21 | | | 38.4 | -0.18 | -2.08 | 0.05 | 1.75 | 1.9 (0.60-G) |
| 45.1-46.5 | 49.7 | 22 | | | 40.1 | -0.15 | -2.44 | -0.31 | 1.40 | 1.9 (0.57-G) |

NOTES: 1. Each nose includes a light nose complete.
2. Nose cross girder setting — 6, 4, and 2 is the position of the cross girder resting on the 6th, 4th, and 2d hole from the bottom of the LNCG post.

11. Loads required.

From Table 2, determine the truck and trailer loads required for the bridge.

TABLE 2

| MGB PALLETS DS w/LRS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Pallet Type | Bays | | | | | | | | | |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| Erection | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Bridge | 9 | 9 | 9 | 10 | 10 | 10 | 11 | 11 | 11 | 12 |
| Link | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Total | 12 | 12 | 12 | 13 | 13 | 13 | 14 | 14 | 14 | 15 |

NOTE: More vehicles are required to transport personnel.

12. Construction time and manpower requirements.

From Table 3, extract the following information:

a. Construction time _____

b. Manpower requirements _____

TABLE 3

| WORKING PARTIES AND BUILDING TIMES ON GOOD SITES | | | |
|---|---|---|---|
| | Double Story Single Span 13-22 Bays w/LRS | | |
| (a) | 13 Bays 33.2M MLC 60 (b) | 18 Bays 42.4M MLC 60 (c) | 22 Bays 49.7M MLC 60 (d) |
| Working Party | 2 + 32 | 2 + 32 | 2 + 32 |
| Time by Day (hours) | 2 | 2 3/4 | 3 |
| Time by Night (hours) | 3 | 4 | 4 1/2 |

NOTES: 1. All times exclusive of work on approaches and so forth.
2. Add 20 percent for unskilled personnel.
3. Add 30 percent for adverse site conditions.

13. Final design.

a. 2E + _____ Bays

b. LNCG setting _____

c. CRB setting _____

d. RB setting _____

e. Bearing

HB _____

FB _____

f. Truck and trailer loads _____

g. Manpower required _____

h. Time to construct _____

## BAILEY BRIDGE TYPE M-2

### Truss

The Bailey bridge trusses are formed from 10-foot panels and may be constructed in any configuration shown in Table 7-28.

**Table 7-28. Truss/story configuration**

| TYPE | | | |
|---|---|---|---|
| TRUSS | STORY | NOMENCLATURE | ABBREVIATION |
| Single | Single | Single-Single | SS |
| Double | Single | Double-Single | DS |
| Triple | Single | Triple-Single | TS |
| Double | Double | Double-Double | DD |
| Triple | Double | Triple-Double | TD |
| Double | Triple | Double-Triple | DT |
| Triple | Triple | Triple-Triple | TT |

## Site Reconnaissance

A site reconnaissance must be conducted. The construction area must provide enough space for equipment layout (Figure 7-18) and for the bridge site layout (Figure 7-19).

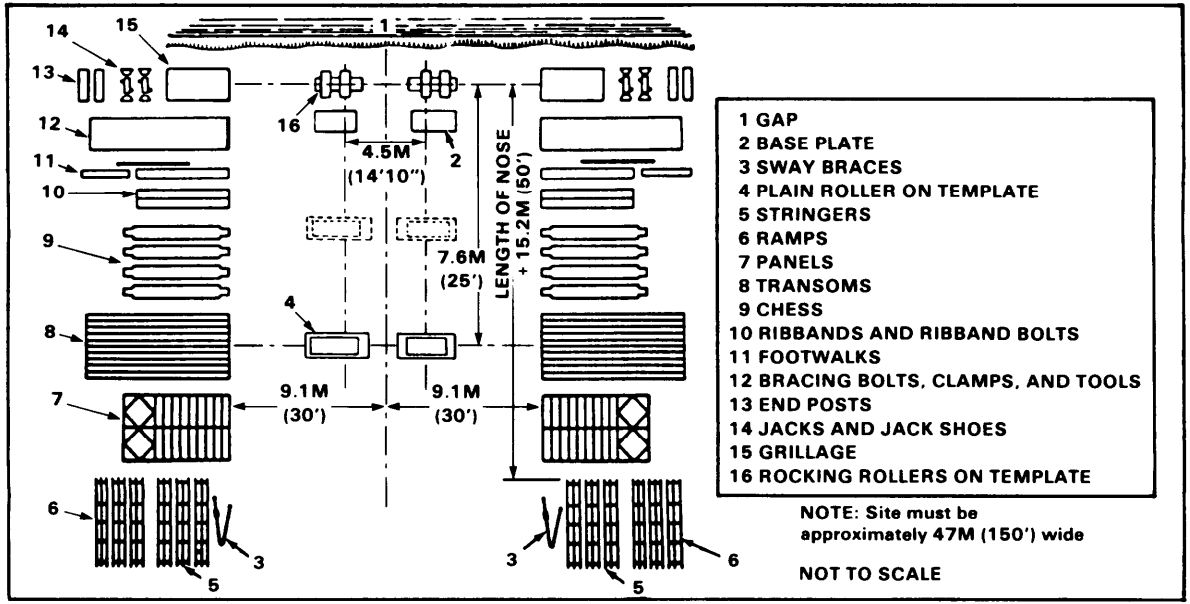



**Figure 7-18. Layout of bridging equipment at site**

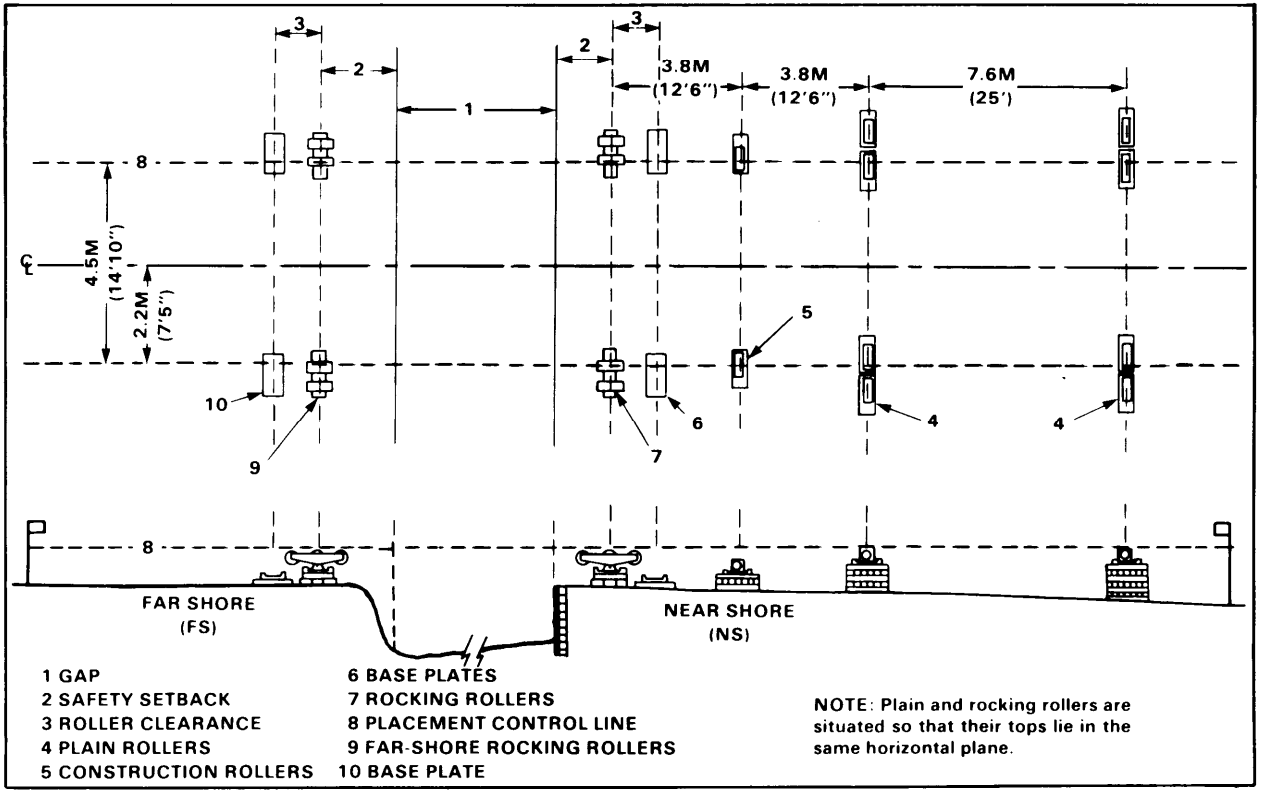



Figure 7-19. Plan and profile views of a typical roller layout for a triple- truss or multistory bridge

## Bridge Design (with example)

See Figure 7-20 and Tables 7-29 through 7-45 (pages 7-54 through 7-68).

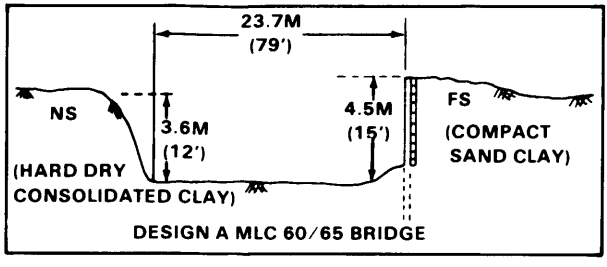



Figure 7-20. Site profile example

### I. INITIAL BRIDGE DESIGN
(Steps 1 through 6)

| | | | |
|---|---|---|---|
| 1. Gap as measured during reconnaissance | 1. | | 79' |
| 2. Safety setback | | | |
| a. Prepared abutment = a constant of 3.5' | 2. | NS | 1.5 x 12 = 18 |
| b. Unprepared abutment = 1.5 x bank height | | FS | 3.5' |
| 3. Initial roller clearance | 3. | NS | 2.5' |
| Always a constant of 2.5' | | FS | 2.5' |
| 4. Initial bridge length: | | | |
| a. Add Steps 1 + 2 + 3. | 4a. | | = 105.5' |
| b. If the value determined in Steps 4a is not a multiple of 10', round UP to the next highest 10' | 4b. | | 110' |
| 5. Initial truss/story type (Table 7-29) | 5. | | DD |
| 6. Initial bridge class (Table 7-29) | 6. | | 65/70 |

a. Class must meet or exceed the requirements designated in the mission statement.

b. The truss/story type selected is always based upon a NORMAL CROSSING unless otherwise directed by the Tactical Commander.

Table 7-29. Classes of Bailey bridge M2 (by type of construction and type of crossing)

| TYPE OF CONSTRUCTION | RATING | SPAN (FT) 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 | 210 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS | N | 30 | 24 | | 20 | 20 | 16 | 12 | 8 | | | | | | | | | | | |
| | | 30 | | 24 | | | | | | | | | | | | | | | | |
| | C | 42 | 36 | 33 | 30 | 24 | 20 | 16 | 12 | | | | | | | | | | | |
| | | 37 | 34 | 31 | 29 | | | | | | | | | | | | | | | |
| | R | 47 | 40 | 36 | 33 | 30 | 24 | 19 | 14 | | | | | | | | | | | |
| | | 42 | 38 | 35 | 32 | 30 | | | | | | | | | | | | | | |
| DS | N | | | 75 | 75 | 60 | 50 | 40 | 30 | 20 | 16 | 12 | 8 | | | | | | | |
| | | | | 70 | 65 | 60 | 55 | 45 | 30 | | | | | | | | | | | |
| | C | | | 83 | 77 | 68 | 60 | 50 | 37 | 30 | 23 | 18 | 14 | | | | | | | |
| | | | | 76 | 73 | 69 | 60 | 50 | 39 | 32 | | | | | | | | | | |
| | R | | | 88 | 85 | 78 | 66 | 55 | 42 | 34 | 27 | 21 | 17 | | | | | | | |
| | | | | 84 | 79 | 75 | 64 | 55 | 44 | 36 | 30 | | | | | | | | | |
| TS | N | | | | | | 85 | 65 | 50 | 35 | 30 | 20 | 16 | 12 | 8 | 4 | | | | |
| | | | | | | | 80 | 65 | 55 | 40 | 35 | | | | | | | | | |
| | C | | | | | | 95 | 74 | 57 | 47 | 38 | 31 | 24 | 18 | 15 | 10 | | | | |
| | | | | | | | 90 | 75 | 60 | 49 | 41 | 33 | | | | | | | | |
| | R | | | | | | 100* | 82 | 64 | 52 | 43 | 35 | 29 | 22 | 17 | 13 | | | | |
| | | | | | | | 90* | 82 | 66 | 54 | 45 | 38 | 31 | | | | | | | |
| DD | N | | | | | | | | 80 | 65 | 45 | 35 | 30 | 24 | 16 | 12 | 8 | | | |
| | | | | | | | | | 80 | 70 | 55 | 45 | 35 | | | | | | | |
| | C | | | | | | | | 86 | 72 | 57 | 47 | 39 | 32 | 25 | 19 | 15 | | | |
| | | | | | | | | | 90 | 76 | 61 | 50 | 42 | 35 | | | | | | |
| | R | | | | | | | | 96 | 80 | 64 | 53 | 44 | 36 | 30 | 24 | 18 | | | |
| | | | | | | | | | 90 | 83 | 68 | 56 | 48 | 40 | 33 | | | | | |
| TD | N | | | | | | | | | 90 | 75 | 55 | 45 | 35 | 30 | 20 | 16 | 12 | | |
| | | | | | | | | | | 90* | 80 | 60 | 55 | 45 | 35 | | | | | |
| | C | | | | | | | | | 100* | 83 | 65 | 57 | 47 | 37 | 31 | 24 | 18 | | |
| | | | | | | | | | | 90* | 90* | 72 | 62 | 51 | 41 | 34 | | | | |
| | R | | | | | | | | | 100* | 91 | 74 | 64 | 54 | 45 | 37 | 29 | 22 | | |
| | | | | | | | | | | 90* | 90* | 80 | 70 | 58 | 48 | 40 | 32 | | | |
| DT | N | | | | | | | | | | | 70 | 70 | 60 | 55 | 45 | 35 | 30 | 20 | 16 |
| | | | | | | | | | | | | 80 | 70 | 60 | 55 | 50 | 45 | 35 | | |
| | C | | | | | | | | | | | 80 | 80 | 77 | 69 | 57 | 48 | 39 | 32 | 25 |
| | | | | | | | | | | | | 90* | 90* | 85 | 78 | 64 | 58 | 43 | 36 | |
| | R | | | | | | | | | | | 90 | 88 | 85 | 80 | 64 | 55 | 46 | 38 | 31 |
| | | | | | | | | | | | | 90* | 90* | 90* | 89 | 74 | 60 | 51 | 43 | 35 |
| TT | N | | | | | | | | | | | | | | 80 | 70 | 55 | 45 | 35 | 24 |
| | | | | | | | | | | | | | | | 75 | 70 | 60 | 55 | 40 | |
| | C | | | | | | | | | | | | | | 100 | 80 | 66 | 59 | 48 | 38 |
| | | | | | | | | | | | | | | | 90* | 90* | 75 | 66 | 52 | 43 |
| | R | | | | | | | | | | | | | | 100* | 90 | 77 | 68 | 55 | 46 |
| | | | | | | | | | | | | | | | 90* | 90* | 87 | 77 | 62 | 51 |

Note:
N=Normal
C=Caution
R=Risk
1 Upper figure represents wheeled-load class
2 Lower figure represents tracked-load class
* Limited by roadway width

7. Selection of grillage.

a. Safe soil bearing (Table 7-30)

7a. NS 5 tons/ft²

FS 3 tons/ft²

Table 7-30. Safe bearing capacity for various soils

| SOIL DESCRIPTION | BEARING VALUES (tons per sq ft) |
|---|---|
| Hardpan overlying rock | 12 |
| Very compact sandy gravel | 10 |
| Loose gravel and sandy gravel, compact sand and gravelly sand; very compact sand, inorganic silt soils | 6 |
| Hard dry consolidated clay | 5 |
| Loose coarse-to-medium sand; medium-compact fine sand | 4 |
| Compact sand clay | 3 |
| Loose fine sand; medium-compact sand, inorganic silt soils | 2 |
| Firm or stiff clay | 1.5 |
| Loose saturated-sand clay soils; medium-soft clay | 1 |

b. Safe soil pressure (Table 7-31)

If the soil bearing capacity values determined in step 7a are not listed in Table 7-31, round DOWN to the closest listed. Use these values for step 7c.

7b. NS 3.5 tons/ft²

FS 2.5 tons/ft²

c. Grillage required.

7c. NS Type 1

FS Type 1

Table 7-31. Types of grillage needed

| TYPE OF CONSTRUCTION | SAFE SOIL PRESSURE (tons per sq ft) | SPAN (FT) 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 | 210 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS | 0.5 | 6,7 | 5,6,7 | 5,6,7 | 4 | 4 | 4 | 4 | 4 | | | | | | | | | | | |
| | 1.0 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | |
| | 2.0 | 1 | None | None | None | None | 1 | 1 | 1 | | | | | | | | | | | |
| | 2.5 | None | None | None | None | None | None | None | None | | | | | | | | | | | |
| | 3.5 | None | None | None | None | None | None | None | None | | | | | | | | | | | |
| DS | 0.5 | | | 6 | 6 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | | | | | | | |
| | 1.0 | | | 6,7 | 5,6,7 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | | | | | | |
| | 2.0 | | | 4 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | |
| | 2.5 | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | |
| | 3.5 | | | 1 | None | None | None | None | None | 1 | 1 | 1 | 1 | | | | | | | |
| TS | 0.5 | | | | | | 6 | 6 | 6,7 | 6,7 | 6,7 | 6,7 | 6 | 6,7 | 6,7 | | | | | |
| | 1.0 | | | | | | 6,7 | 5,6,7 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | | | | |
| | 2.0 | | | | | | 4 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | | | | | |
| | 2.5 | | | | | | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | |
| | 3.5 | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | |
| DD | 0.5 | | | | | | | | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | | | |
| | 1.0 | | | | | | | | 6,7 | 5,6,7 | 5,6,7 | 4 | 4,6,7 | 4,6,7 | 4,6,7 | 4,6,7 | 4,6,7 | | | |
| | 2.0 | | | | | | | | 4 | 4 | 3 | 2 | 2 | 4,6,7 | 2 | 4,6,7 | 2 | | | |
| | 2.5 | | | | | | | | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | | | |
| | 3.5 | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| TD | 0.5 | | | | | | | | | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | | |
| | 1.0 | | | | | | | | | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | | |
| | 2.0 | | | | | | | | | 4,6,7 | 4,6,7 | 4,6 | 4,6,7 | 4,6,7 | 4,6,7 | 4,6,7 | 4,6,7 | 4,6,7 | | |
| | 2.5 | | | | | | | | | 4,6,7 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | |
| | 3.5 | | | | | | | | | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | | |
| DT | 0.5 | | | | | | | | | | | 6 | | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| | 1.0 | | | | | | | | | | | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 |
| | 2.0 | | | | | | | | | | | 6,7 | 4,6,7 | 4,6,7 | 6,7 | 6,7 | 6,7 | 4,6,7 | 4,6,7 | 4,6,7 |
| | 2.5 | | | | | | | | | | | 6,7 | 4,6,7 | 4,6,7 | 6,7 | 6,7 | 6,7 | 4,6,7 | 4,6,7 | 4,6,7 |
| | 3.5 | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| TT | 0.5 | | | | | | | | | | | | | | | 6 | 6 | 6 | 6 | 6 |
| | 1.0 | | | | | | | | | | | | | | | 6,7 | 6,7 | 6,7 | 6,7 | 6,7 |
| | 2.0 | | | | | | | | | | | | | | | 6,7 | 6,7 | 6,7 | 6,7 | 4,6,7 |
| | 2.5 | | | | | | | | | | | | | | | 6,7 | 6,7 | 6,7 | 6,7 | 4,6,7 |
| | 3.5 | | | | | | | | | | | | | | | 6,7 | 6,7 | 2 | 2 | 2 |

8. Determine adjusted bridge length:
   a. Distance required for new roller clearance (Table 7-32).
   b. Add steps 1 + 2 + 8a.
   c. If the value determined in step 8b is not a multiple of 10', round UP to the next highest 10'.

NOTE: Compare the value determined in step 8c to the value previously calculated in step 4b. If different, you must redesign the bridge as outlined in steps 9 through 12. If not, use this as your final bridge length and go directly to step 13.

| | | |
|---|---|---|
| 8a. | NS | 4.5' |
| | FS | 4.5' |
| 8b. | | = 109.5' |
| 8c. | | 110' |

Same as initial, go to step 13.

Table 7-32. Roller clearance and grillage height

| GRILLAGE TYPE | OVERALL HEIGHT (IN) | BASE-PLATE HEIGHT (IN) | ROLLER CLEARANCE (FT) |
|---|---|---|---|
| 1 | 6 | 6 | 4.5 |
| 2 | 15 | 6 | 4.5 |
| 3 | 11 | 11 | 3.5 |
| 4 | 17 | 11 | 4.5 |
| 5 | 16 | 16 | 3.5 |
| 6 | 26 | 20 | 3.5 |
| 7 | 13 | 13 | 3.5 |

| | FINAL BRIDGE Try 1 | Try 2 |
|---|---|---|
| 9. | | |
| 10. | | |

9. Final truss/story type (Table 7-29, page 7-53).

10. Final bridge class (Table 7-29, page 7-53).
   a. Class must meet or exceed the requirements designated in the mission statement.
   b. The truss/story type selected is always based upon a NORMAL CROSSING unless otherwise directed by the Tactical Commander.

| | | | |
|---|---|---|---|
| 11a. | NS | | |
| | FS | | |
| 11b. | NS | | |
| | FS | | |
| 11c. | NS | Type | Type |
| | FS | Type | Type |

11. Final grillage selection:
   a. Safe soil bearing (Table 7-30, page 7-54).
   b. Safe soil pressure (Table 7-31, page 7-55). If the soil bearing capacity values determined in step 11a are not listed in Table 7-31, round DOWN to the closest listed. Use these values for step 11c.
   c. Grillage required.

12. Determine final bridge length:

a. Distance required for new roller clearance (Table 7-32).

b. Add steps 1 + 2 + 12a.

c. If the value determined in step 12b is not a multiple of 10', round UP to the next highest 10'.

| | | |
|---|---|---|
| 12a. NS | | |
| FS | | |
| 12b. | = | = |
| 12c. | | |

NOTES. 1. For Try 1: Compare the value in step 12c to the value in step 8c. If the same, go to step 13. If different, compare this value (step 12c) to the value in step 4b:

a. If these are the same, the designer is placed in a judgmental situation. Repeating the design sequence under the Try 2 column, using the bridge length from step 12c of Try 1 column, will place you in an endless circle unless the final bridge length can be reduced. In these cases, you will have to either overdesign a longer final bridge as shown in the Try 1 column or choose a higher number grillage than originally selected in step 7c. The latter procedure could reduce the roller clearance on one or both banks so that the required bridge length/final truss/story may be at the minimum to do the job. You may choose a higher number grillage than allowed within step 11c, however, you must be careful not to exceed the BP and RRT capacities listed in FM 5-277, Tables 4-2 and 4-3. Make your decision and go to step 13.

b. If these are different, you must redesign the bridge by entering the Try 2 column with the bridge length from step 12c of Try 1 columnto determine the truss/story type in step 9.

2. For Try 2 and Higher: Compare the value in step 12c to the value in step 12c of the previous Try ___ column. If the same, go to step 13. If different, use the same methodology and repeat the design sequence until the value obtained in a particular step 12c matches the value in step 12c of the previous design. Then go to step 13.



13. Slope check:

a. The maximum allowable bank height difference is 1 to 30. Therefore, maximum allowable bank height difference = final bridge length ÷ 30.

b. If:

(1) The step 13a value ≥ actual bank height difference, the slope is all right.

(2) The step 13a value < actual bank height difference:

(a) Choose another site, or

(b) Crib up/excavate the FS or NS until the bridge slope is within acceptable limits.

13a. 110 ÷ 30 = 3.7' > 3'

13b. GO/NO GO (circle)

Remarks:

14. Final bridge requirements:

Length: 110'

Truss/story type: DD

Class: 65/70

Grillage:

NS: Type 1

FS: Type 1

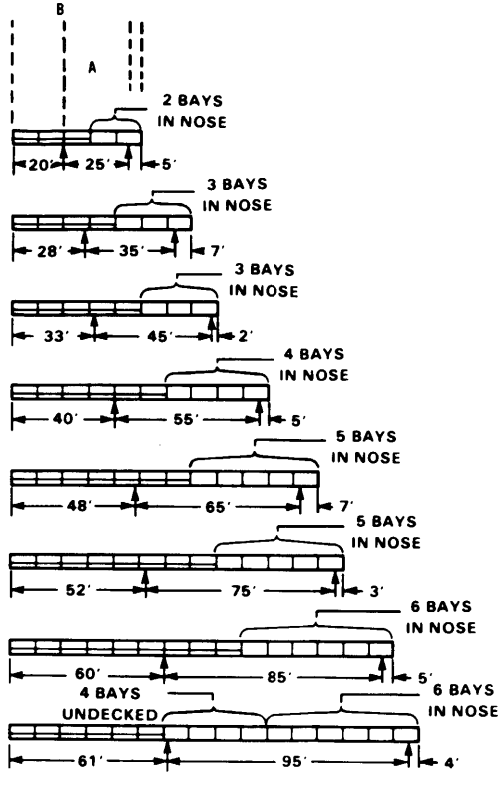
15. Launching nose composition (use Tables 7-33 through 7-39, pages 7-58 through 7-64 dependent upon truss/story type).

15. 7 bays single truss

NOTE: Design sequence continues on page 7-64.

Table 7-33. Launching-nose composition for SS bridges

| SPAN (FEET) | LAUNCHING WT (TONS) | SAG (INCHES) |
|---|---|---|
| 30 | 11.0 | 3 |
| 40 | 14.5 | 4 |
| 50 | 17.5 | 5 |
| 60 | 21.0 | 8 |
| 70 | 25.0 | 12 |
| 80 | 27.5 | 15 |
| 90 | 31.5 | 25 |
| 100 | 28.5 | 33 |



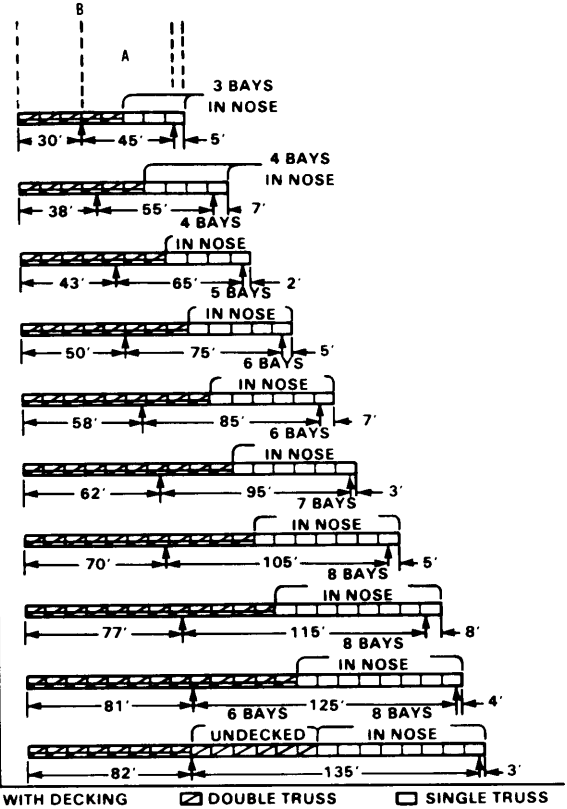

SINGLE TRUSS WITH DECKING

SINGLE TRUSS

NOTES: A. Distance between near and far bank rocking rollers.
B. Balance point of bridge, ready for launching.

Table 7-34. Launching-nose composition for DS bridges

| SPAN (FEET) | LAUNCHING WT (TONS) | SAG (INCHES) |
|---|---|---|
| 50 | 24.0 | 4 |
| 60 | 25.0 | 7 |
| 70 | 28.5 | 9 |
| 80 | 33.0 | 14 |
| 90 | 37.0 | 20 |
| 100 | 40.5 | 23 |
| 110 | 45.0 | 33 |
| 120 | 49.5 | 46 |
| 130 | 53.0 | 52 |
| 140 | 47.5 | 63 |

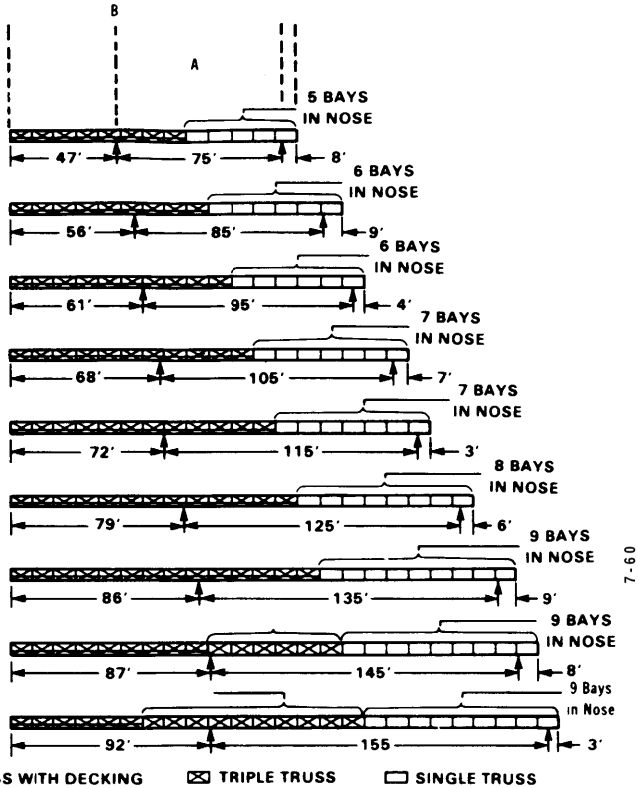



DOUBLE TRUSS WITH DECKING  DOUBLE TRUSS  SINGLE TRUSS

NOTES: A. Distance between near and far bank rocking rollers.
B. Balance point of bridge, ready for launching.

Table 7-35. Launching-nose composition for TS bridges

| SPAN (FEET) | LAUNCHING WT (TONS) | SAG (INCHES) |
|---|---|---|
| 80 | 43.4 | 13 |
| 90 | 42.5 | 19 |
| 100 | 46.5 | 22 |
| 110 | 51.5 | 30 |
| 120 | 55.5 | 34 |
| 130 | 60.5 | 47 |
| 140 | 65.5 | 62 |
| 150 | 60.5 | 70 |
| 160 | 59.0 | 77 |

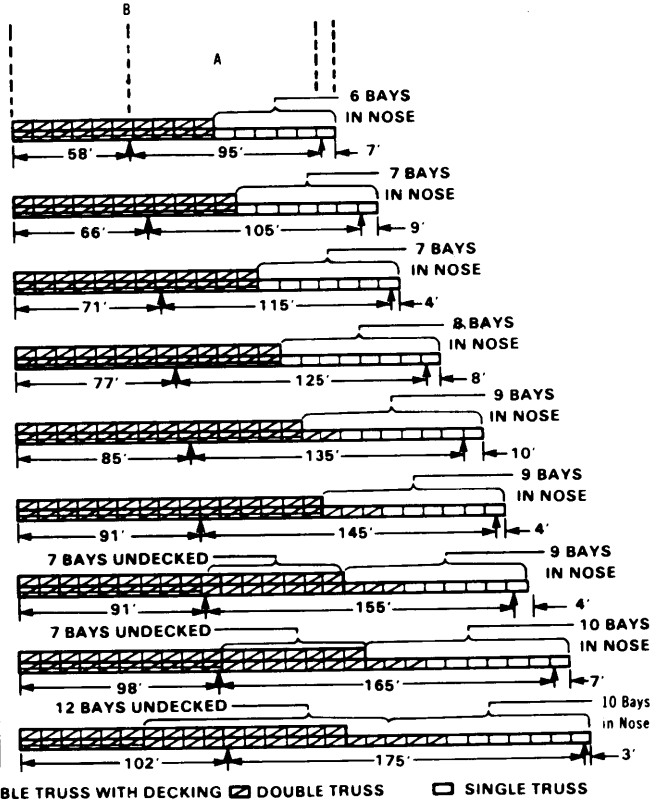



TRIPLE TRUSS WITH DECKING  TRIPLE TRUSS  SINGLE TRUSS

NOTES: A. Distance between near and far bank rocking rollers.
B. Balance point of bridge, ready for launching.

Table 7-36. Launching-nose composition for DD bridges

| SPAN (FEET) | LAUNCHING WT (TONS) | SAG (INCHES) |
|---|---|---|
| 100 | 60.5 | 17 |
| 110 | 59.0 | 22 |
| 120 | 63.5 | 24 |
| 130 | 69.0 | 31 |
| 140 | 76.0 | 38 |
| 150 | 81.5 | 41 |
| 160 | 75.5 | 45 |
| 170 | 81.0 | 57 |
| 180 | 76.0 | 68 |

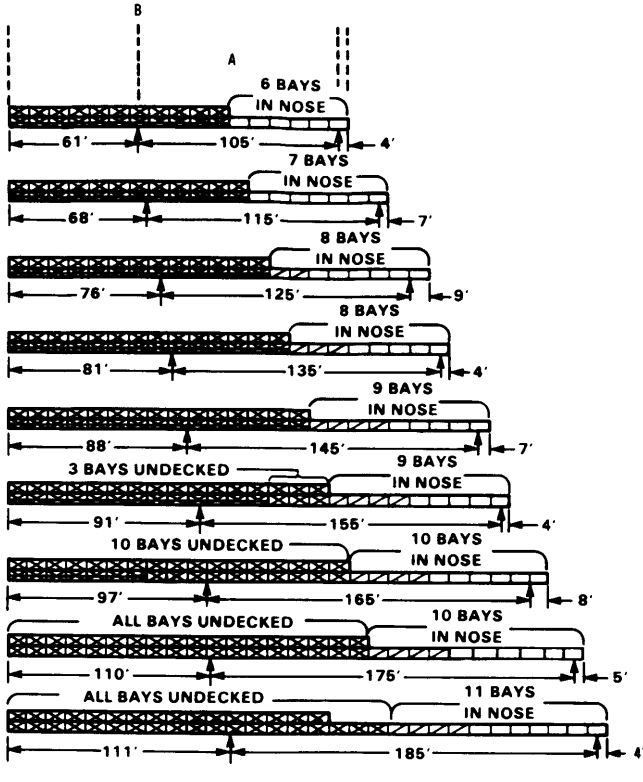



DOUBLE TRUSS WITH DECKING  DOUBLE TRUSS  SINGLE TRUSS

NOTES: A. Distance between near and far bank rocking rollers.
B. Balance point of bridge, ready for launching.

Table 7-37. Launching-nose composition for TD bridges

| SPAN (FEET) | LAUNCHING WT (TONS) | SAG (INCHES) |
|---|---|---|
| 110 | 79.4 | 17 |
| 120 | 87.1 | 22 |
| 130 | 86.0 | 29 |
| 140 | 93.0 | 31 |
| 150 | 100.0 | 39 |
| 160 | 101.5 | 42 |
| 170 | 98.0 | 53 |
| 180 | 93.5 | 60 |
| 190 | 91.5 | 78 |

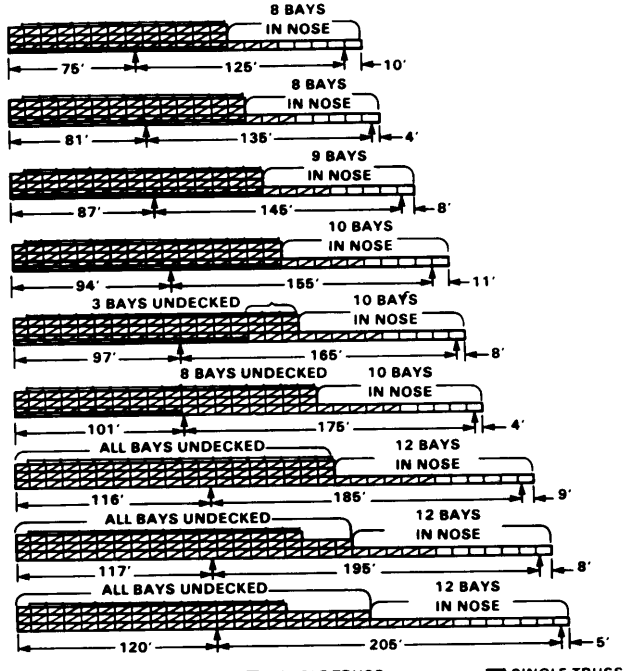



TRIPLE TRUSS WITH DECKING  TRIPLE TRUSS  DOUBLE TRUSS  SINGLE TRUSS

NOTES: A. Distance between near and far bank rocking rollers.
B. Balance point of bridge, ready for launching.

Table 7-38. Launching-nose composition for DT bridges

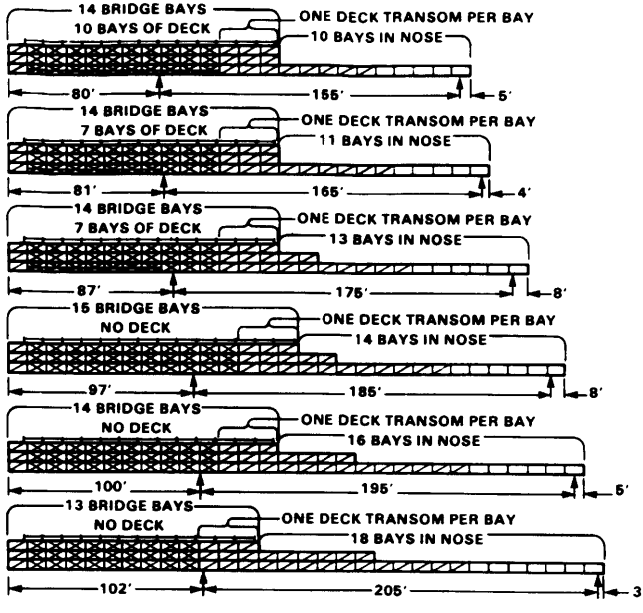
| SPAN (FEET) | LAUNCHING WT (TONS) | SAG (INCHES) |
|---|---|---|
| 130 | 104.2 | 25 |
| 140 | 101.0 | 27 |
| 150 | 109.0 | 34 |
| 160 | 117.0 | 42 |
| 170 | 119.0 | 45 |
| 180 | 118.5 | 47 |
| 190 | 111.0 | 60 |
| 200 | 110.5 | 72 |
| 210 | 112.0 | 80 |




DOUBLE TRUSS WITH DECKING  DOUBLE TRUSS  SINGLE TRUSS

Table 7-39. Launching-nose composition for TT bridges

| SPAN (FEET) | LAUNCHING WT (TONS) | SAG (INCHES) |
|---|---|---|
| 160 | 126.5 | 40 |
| 170 | 112.5 | 45 |
| 180 | 119.0 | 50 |
| 190 | 116.0 | 62 |
| 200 | 115.0 | 72 |
| 210 | 113.5 | 80 |




16. Placement of launching nose links:

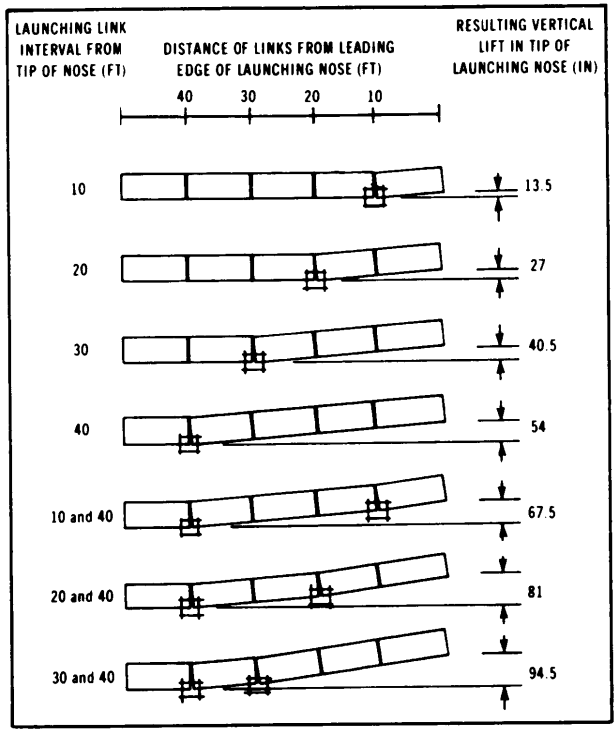
a. Sag (use the same table as step 15). 16a. 22"

b. Safety sag (constant of 6"). 16b. + 6"

c. Lift required (add steps 16a + 16b). 16c. = 28"

d. Position of launching nose link (Table 7-40). 16d. 30' from tip of nose

Table 7-40. Upturned skeleton launching nose




17. Rocking rollers needed (Table 7-41) 17. NS 4

FS 2

Table 7-41. Number of rocking rollers needed for bridge

| TYPE OF CONSTRUCTION | SPAN (FT) | NEAR BANK | FAR BANK |
|---|---|---|---|
| SS | 30-100 | 2 | 2 |
| DS | 50-80 | 2 | 2 |
| | 90-100 | 2 | 2 |
| | 110-140 | 4 | 2 |
| TS | 80-160 | 4 | 2 |
| DD | 100-130 | 4 | 2 |
| | 140-180 | 4 | 4 |
| TD | 110-120 | 4 | 2 |
| | 130-190 | 4 | 4 |
| DT | 130-210 | 4 | 4 |
| TT | 160-210 | 4 | 4 |

18. Plain rollers needed:

a. The SS and DS bridges only have two rollers per row. All others have four rollers per row. Use Table 7-42 to determine the number of rows and then multiply. 18a. 12

Table 7-42. Rows of plain rollers needed for bridge

| SPAN (FT) | TYPE OF CONSTRUCTION SS | DS | TS | DD | TD | DT | TT |
|---|---|---|---|---|---|---|---|
| 30-50 | 1 | 1 | | | | | |
| 60-80 | 2 | 2 | 2 | | | | |
| 90 | 3 | 2 | 2 | | | | |
| 100 | 3 | 3 | 2 | 2 | | | |
| 110-120 | | 3 | 3 | 3 | 3 | | |
| 130 | | 3 | 3 | 3 | 3 | 3 | |
| 140 | | 3 | 4 | 4 | 3 | 3 | |
| 150 | | | 4 | 4 | 4 | 4 | |
| 160 | | | 4 | 4 | 4 | 4 | 3 |
| 170 | | | | 4 | 4 | 4 | 3 |
| 180 | | | | 4 | 5 | 4 | 4 |
| 190 | | | | | 5 | 5 | 4 |
| 200-210 | | | | | | 5 | 4 |

b. Add two more plain rollers to allow for your construction roller needs. 18b. +2

c. Add steps 18a + 18b. 18c. = 14

19. Jacks required (Table 7-43). 19. 4

NOTE: Only one end of the bridge will be jacked down at any one time.

Table 7-43. Number of jacks

| TYPE OF CONSTRUCTION | SPAN (FT) | JACKS NEEDED AT EACH END OF BRIDGE |
|---|---|---|
| SS | 30-100 | 2 |
| DS | 50-140 | 4 |
| TS | 80-140 | 4 |
| | 150-160 | 6 |
| DD | 100-120 | 4 |
| | 130-180 | 6 |
| TD | 110-140 | 6 |
| | 150-190 | 8 |
| DT | 130 | 6 |
| | 140-180 | 8 |
| | 190-210 | 10 |
| TT | 160-170 | 10 |
| | 180-210 | 12 |

20. Ramp requirements.

a. Slope requirements (check one).

(1) Final bridge class ≤ 50 = 1 to 10. ( )

(2) Final bridge class > 50 = 1 to 20. (x)

b. Support for end ramp (check one).

(1) Final bridge class ≤ 67 = 2 chess. ( )

(2) Final bridge class > 67 = 4 chess. (x)

c. Midspan ramp supports (check one).

(1) Final bridge class ≤ 44 = not needed. ( )

(2) Final bridge class > 44 = needed. (x)

d. Pedestal supports (check one).

(1) Not needed. ( )

(2) Needed. (x)

NOTE: See FM 5-277 for criteria and drawings. Ramp lengths must be estimated from the site sketch.

e. Support for end transom (check one).

(1) Final bridge class ≤ 39 = not needed. ( )

(2) Final bridge class > 39 = needed. (x)

NOTE: The differences between manpower and crane construction.

Table 7-44. Organization of assembly party

| DETAIL | TYPE OF CONSTRUCTION | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SS | | DS | | TS | | DD | | TD | | DT | | TT | | DT | | TT | |
| | CONSTRUCTION BY MANPOWER ONLY | | | | | | | | | | | | | | USING ONE CRANE* | | | |
| | NCO | EM | NCO | EM | NCO | EM | NCO | EM | NCO | EM | NCO | EM | NCO | EM | NCO | EM | NCO | EM |
| Crane | | | | | | | | | | | | | | | 0 | 3 | 0 | 3 |
| Truck driver | | | | | | | | | | | | | | | | 1 | | 1 |
| Crane operator | | | | | | | | | | | | | | | | 1 | | 1 |
| Hook man | | | | | | | | | | | | | | | | 1 | | 1 |
| Panel | 1 | 14 | 1 | 14 | 2 | 28 | 2 | 32 | 3 | 50 | 3 | 50 | 3 | 68 | 3 | 30 | 3 | 30 |
| Carrying | | 12 | | 12 | | 24 | | 28 | | 44 | | 44 | | 60 | | 24 | | 24 |
| Pin | | 2 | | 2 | | 4 | | 4 | | 6 | | 6 | | 8 | | 6 | | 6 |
| Transom | 1 | 9 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 2 | 28 | 2 | 28 | 2 | 20 | 2 | 20 |
| Carrying | | 8 | | 8 | | 8 | | 8 | | 8 | | 24 | | 24 | | 16 | | 16 |
| Clamp | | 1 | | 2 | | 2 | | 2 | | 2 | | 4 | | 4 | | 4 | | 4 |
| Bracing | 1 | 4 | 1 | 6 | 1 | 8 | 1 | 12 | 1 | 20 | 1 | 32 | 1 | 40 | 1 | 32 | 1 | 38 |
| Sway brace | | 2 | | 2 | | 2 | | 2 | | 2 | | 6 | | 6 | | 6 | | 6 |
| Raker | | 2 | | 2 | | 2 | | 2 | | 2 | | 2 | | 2 | | 2 | | 2 |
| Bracing frame | | | | 2 | | 2 | | 4 | | 4 | | 8 | | 8 | | 10 | | 8 |
| Chord bolt | | | | | | | | 4 | | 8 | | 10 | | 14 | | 10 | | 14 |
| Tie plate | | | | | | 2 | | | | 4 | | | | 4 | | | | 4 |
| Overhead support | | | | | | | | | | | | 6 | | 6 | | 4 | | 4 |
| Decking | 1 | 12 | 1 | 12 | 1 | 12 | 1 | 12 | 1 | 12 | 1 | 12 | 1 | 12 | 1 | 12 | 1 | 12 |
| Stringer | | 8 | | 8 | | 8 | | 8 | | 8 | | 8 | | 8 | | 8 | | 8 |
| Chess and ribband | | 4 | | 4 | | 4 | | 4 | | 4 | | 4 | | 4 | | 4 | | 4 |
| Total | 4 | 39 | 4 | 42 | 5 | 58 | 5 | 66 | 6 | 92 | 7 | 122 | 7 | 148 | 7 | 97 | 7 | 103 |

* Normally, a crane is not used for single- or double-story assembly.

22. Assembly time (Table 7-45). 22. 5 hr

NOTE: This time allows for ideal bridge construction conditions and does not allow for site preparation or roller layout.

**Table 7-45. Estimated time for assembly**

| SPAN (FT) | TYPE OF CONSTRUCTION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | SS | DS | TS | DD | TD | DT | TT | DT | TT |
| | TIME (HR) | | | | | | | | |
| | CONSTRUCTION BY MANPOWER ONLY | | | | | | | USING ONE CRANE | |
| 40 | 1 1/2 | | | | | | | | |
| 60 | 1 3/4 | 2 | | | | | | | |
| 80 | 2 | 2 1/2 | 3 | | | | | | |
| 100 | 2 1/4 | 3 | 3 1/2 | 4 1/4 | | | | | |
| 120 | | 3 1/2 | 4 | 5 | 6 3/4 | | | | |
| 140 | | 3 3/4 | 4 1/2 | 5 3/4 | 7 1/2 | 11 3/4 | | 10 1/2 | |
| 160 | | | 5 | 6 1/4 | 8 1/2 | 13 1/4 | 19 | 11 3/4 | 16 1/4 |
| 180 | | | | 7 | 9 1/2 | 14 3/4 | 21 1/4 | 13 1/4 | 18 1/4 |
| 200 | | | | | | 16 1/4 | 24 | 14 1/2 | 20 1/2 |

## HASTY NONSTANDARD FIXED BRIDGES

This paragraph describes the procedures for designing a hasty, one-lane fixed bridge. MLC 30 or MLC 70.

NOTE: This is only a temporary design. Refer to TM 5-312 for design of a semipermanent timber trestle bridge.

### Nomenclature

**Superstructure**

The load carrying component of the superstructure is the stringer system, which may be rectangular timber, round timber, or steel beams.

**Substructure**

Intermediate supports are required if the available material is not long enough or of sufficient capacity to cross the required gap. Abutments are always required a each end of the bridge.

### Superstructure Design - Timber Stringers

Step 1. Determine the gap length and MLC (either MLC 30 or MLC 70).

Step 2. Determine the size of available structural timber. For round timbers, use the average diameter.

Step 3. Use Table 7-46, enter at the top with the stringer size (round DOWN if available size is not listed), then read down to appropriate gap size and desired MLC to find the number of stringers per span required. If no number is listed, use two or more shorter spans.

**Table 7-46. Number of timber stringers required**

| SPAN LENGTH M (FT) | MLC | RECTANGULAR - bxd | | | | | | | | | | | | | | | | ROUND - d | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SIZE OF TIMBER IN CM (IN) | | 20x46 (8x18)* | 20x61 (8x24)* | 25x30 (10x12) | 25x46 (10x18) | 25x61 (10x24)* | 30x30 (12x12) | 30x46 (12x18) | 30x61 (12x24) | 36x36 (14x14) | 36x46 (14x18) | 36x61 (14x24) | 41x46 (16x18) | 41x61 (16x24) | 46x46 (18x18) | 46x61 (18x24) | 30 (12) | 36 (14) | 41 (16) | 46 (18) | 51 (20) | 56 (22) | 61 (24) |
| 3 (10) | 30 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| | 70 | | 4 | | | 4 | | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | 7 | 4 | 4 | 4 | 4 | 4 |
| 4.5 (15) | 30 | 4 | 4 | 6 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | 6 | 4 | 4 | 4 | 4 | 4 |
| | 70 | | 6 | | | 4 | | 5 | 4 | 8 | 5 | 4 | 4 | 4 | 4 | 4 | | | 9 | 6 | 4 | 4 | 4 |
| 6 (20) | 30 | 6 | 4 | | 5 | 4 | | 4 | 4 | | 4 | 4 | 4 | 4 | 4 | 4 | | | 7 | 5 | 4 | 4 | 4 |
| | 70 | | | | | 6 | | 10 | 5 | | 8 | 4 | 7 | 4 | 6 | 4 | | | | 11 | 8 | 6 | 4 |
| 7.5 (25) | 30 | 8 | 4 | | | 4 | | | 4 | | | 4 | | 4 | | 4 | | | | | | 4 | 4 |
| | 70 | | | | | 11 | | | 8 | | | 6 | | 5 | | 4 | | | | | | 8 | 6 |

*Lateral bracing required

(Chart assumes structural quality timbers in good condition.)

Step 4. Use Table 7-47 to determine the required deck thickness based on MLC and number of stringers.

**Table 7-47. Required deck thickness - CM (in)**

| MLC \ NUMBER OF STRINGERS | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 13.9 (5.5) | 11.3 (4.5) | 10.1 (4) | 8.8 (3.5) | 7.6 (3) | 7.6 (3) | 7.6 (3) | 7.6 (3) | 7.6 (3) | 7.6 (3) |
| 70 | 20.2 (8) | 17.6 (7) | 15.1 (6) | 12.6 (5) | 10.1 (4) | 7.6 (3) | 7.6 (3) | 7.6 (3) | 7.6 (3) | 7.6 (3) |

Step 5. Lateral braces are required for those stringers listed with an asterick in Table 7-46 (page 7-69) or if d is greater than 2b. If lateral braces are needed, they should have a depth of half the stringer depth and a minimum width of 3 inches. Locate the braces at the ends and the midpoint of the span and in the top half of the stringer (Figure 7-21).

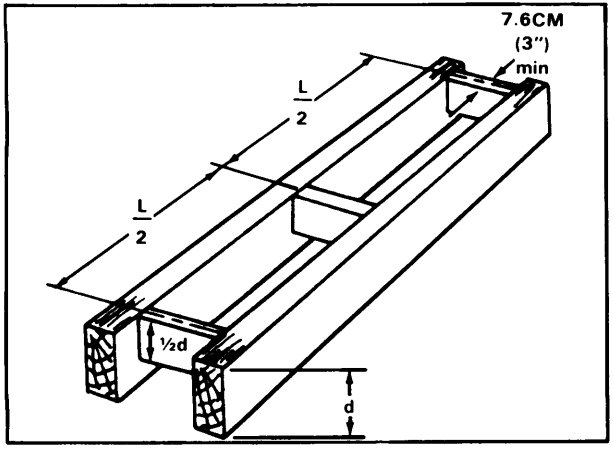



**Figure 7-21. Lateral bracing for timber stringers**

Step 6. Curbs, handrails and a wearing surface can be omitted for hasty bridges Figure 7-22 illustrates a cross-section of a hasty MLC 30 to MLC 70 one-lane timber stringer bridge.

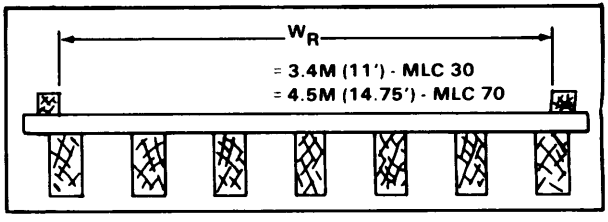



**Figure 7-22. One-lane hasty timber stringer fixed bridge**

**Superstructure Design - Steel Stringers**

Step 1. Determine the gap length and MLC (either MLC 30 or MLC 70)

Step 2. Measure the depth (d) and the base (b) of the available steel sections to the nearest quarter inch or centimeter.

Step 3. Use Table 7-48, enter at the top with the stringer size (round DOWN if the exact dimensions are not listed), then read down to the appropriate gap size and desired MLC to find the number of stringers per span required. If no number is listed. use two or more shorter spans.

Step 4. Use Table 7-47 (page 7-69) to determine the required deck thickness based on MLC and number of stringers.

Table 7-48. Number of steel stringers required
(number of lateral braces)

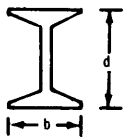
| SPAN LENGTH M (FT) | MLC \ SIZE OF STEEL - dxb CM (IN) | 30.5x12.5 (12x5) | 30.5x20 (12x8) | 35.5x15 (14x6) | 35.5x30 (14x11.75) | 40.5x17.5 (16x7) | 40.5x30 (16x11.75) | 45.5x17.5 (18x7) | 45.5x30 (18x11.75) | 53x20 (21x8) | 61x20 (24x8) | 61x30 (24x11.75) | 68.5x25 (27x10) | 76x26.5 (30x10.5) | 83.5x29 (33x11.5) | 83.5x40 (33x15.75) | 91.5x30.5 (36x12) | 91.5x42 (36x16.5) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.5 (25) | 30 | 10 (5) | 8 (3) | 8 (6) | 4 (3) 6 | 5 (5) 15 | 4 (3) 5 | 4 (5) 10 | 4 (3) 4 | 4 (5) 7 | 4 (4) 5 | 4 (3) 4 | 4 (4) 4 | 4 (4) 4 | 4 (4) 4 | 4 (3) 4 | 4 (4) 4 | 4 (3) 4 |
| | 70 | | | | | | | | | | | | | | | | | |
| 9 (30) | 30 | | | 10 (6) | 4 (3) 8 | 6 (6) | 4 (3) 7 | 4 (5) 14 | 4 (3) 4 | 4 (5) 10 | 4 (5) 6 | 4 (4) 4 | 4 (5) 4 | 4 (5) 4 | 4 (4) 4 | 4 (3) 4 | 4 (4) 4 | 4 (3) 4 |
| | 70 | | | | | | | | | | | | | | | | | |
| 10.5 (35) | 30 | | | | 4 (3) 11 | 8 (7) | 4 (3) 9 | 6 (6) | 4 (3) 4 | 4 (6) 12 | 4 (6) 8 | 4 (4) 5 | 4 (5) 5 | 4 (5) 4 | 4 (5) 4 | 4 (3) 4 | 4 (5) 4 | 4 (3) 4 |
| | 70 | | | | | | | | | | | | | | | | | |
| 12 (40) | 30 | | | | 4 (3) 13 | 10 (8) | 4 (3) 11 | 7 (7) | 4 (3) 5 | 5 (6) 14 | 4 (6) 10 | 4 (4) 6 | 4 (6) 6 | 4 (6) 5 | 4 (5) 4 | 4 (4) 4 | 4 (5) 4 | 4 (4) 4 |
| | 70 | | | | | | | | | | | | | | | | | |
| 13.5 (45) | 30 | | | | 5 (3) 15 | 11 (8) | 4 (3) 13 | 8 (7) | 4 (3) 6 | 5 (7) | 4 (7) 11 | 4 (5) 7 | 4 (6) 8 | 4 (6) 6 | 4 (6) 4 | 4 (4) 4 | 4 (6) 4 | 4 (4) 4 |
| | 70 | | | | | | | | | | | | | | | | | |
| 15.1 (50) | 30 | | | | 6 (3) | | 5 (4) 15 | 9 (8) | 4 (4) 7 | 6 (8) | 4 (7) 13 | 4 (5) 8 | 4 (7) 9 | 4 (7) 7 | 4 (6) 4 | 4 (4) 4 | 4 (6) 4 | 4 (4) 4 |
| | 70 | | | | | | | | | | | | | | | | | |

Number of Stringers MLC 30

Number of Braces

Number of Stringers MLC 70

5
(4)
15




(Chart assumes structural quality steel Fy 33 KSI )

Step 5. Lateral braces are always required for steel stringers. Use Table 7-48 (page 7-71 (to determine the number of braces between each stringer. Figure 7-23 shows how to install hasty lateral braces. If steel is used for bracing, it is not necessary to weld it as long as the bridge is of a temporary nature. Attach steel as shown in Figure 7-24 for timber.

Step 6. Curbs, handrails, and a wearing surface can be omitted for hasty bridges Figure 7-23 illustrates a cross-section of a hasty MLC 30 or MLC 70 one-lane steel strtnger bridge.

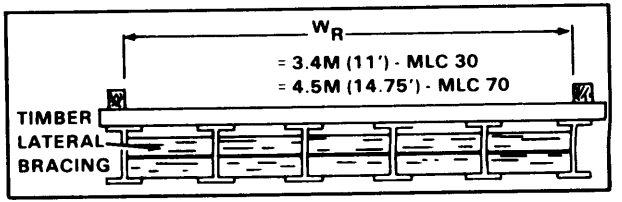



Figure 7-23. One-lane hasty steel stringer fixed bridge

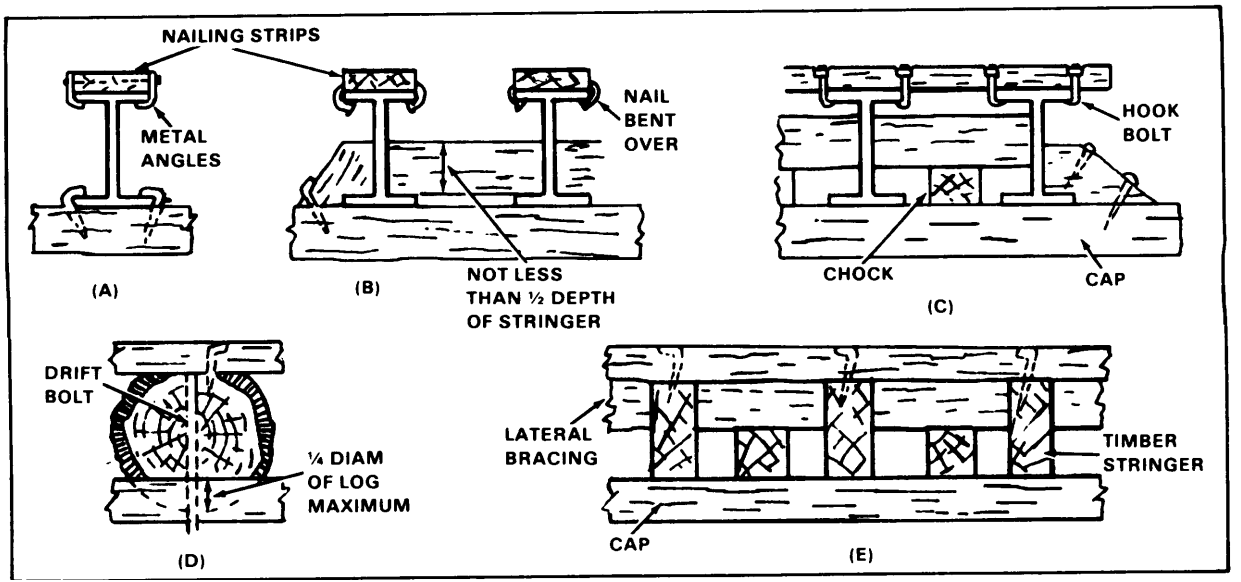



Figure 7-24. Alternate methods of securing stringers and nailing strips

### Substructure Design - Abutments

Abutments act as the interface between the bridge and the ground and must be able to adequately spread the bridge loads into the soil without danger of soil failure, abutment overturning, or abutment sliding. The easiest design for hasty temporary construction is a timber sil abutment (Figure 7-25). Piles or concrete abutments should be used for permanent design Refer to TM 5-312 for design procedures.

### Substructure Design - Intermediate Supports

For hasty temporary construction, a crib pier can be constructed from available materials. Crib piers will be rarely used in heights over 15 feet (4.6 meters). When small sized timber is the only available material, cribs can be successfully built to heights of 20 feet (6 meters) or more. Hasty piers can also be constructed of rubble, rocks, vehicles. Bailey bridge parts, or any other available support material. The TM 5-312 outlines the design procedure for timer trestle, timber pile and steel framed intermediate supports.

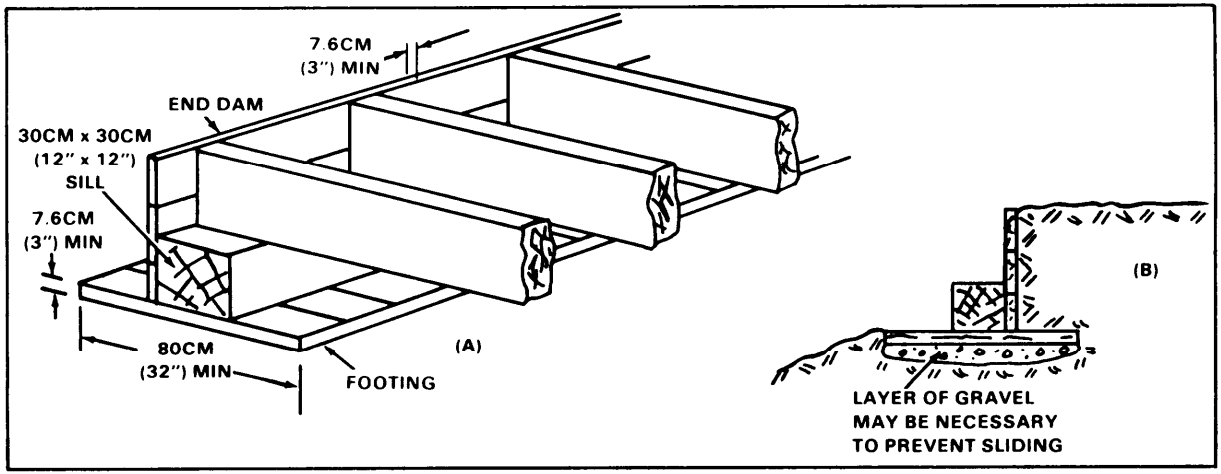



Figure 7-25. Timber sill abutment

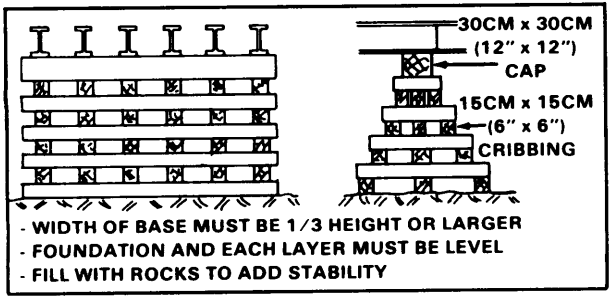



Figure 7-26. Timber crib piers

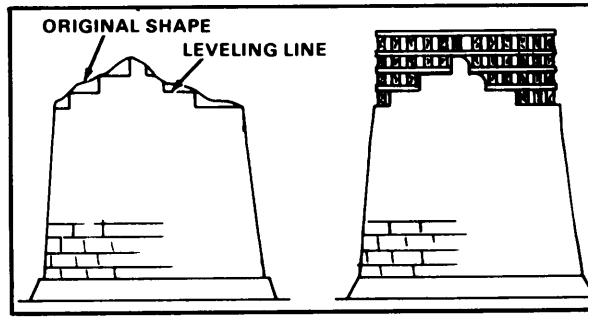



Figure 7-27. Leveling the top of a damaged pier

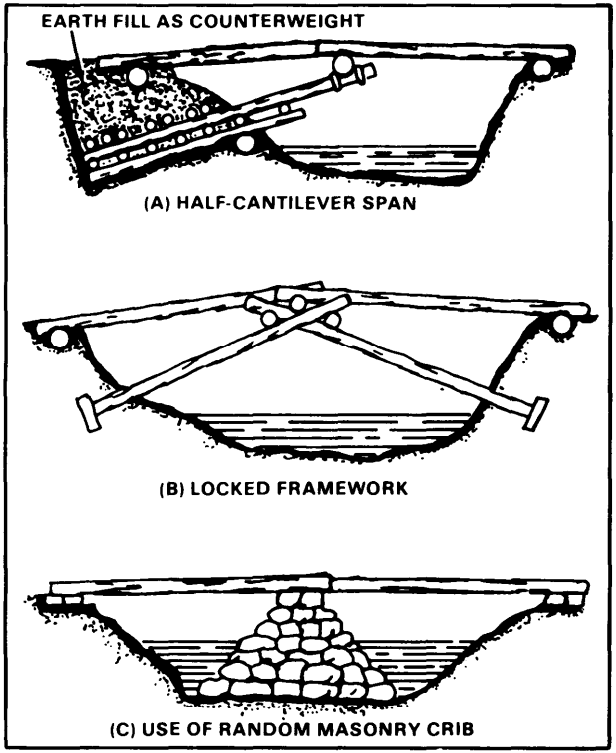



Figure 7-28. Timber spar bridges

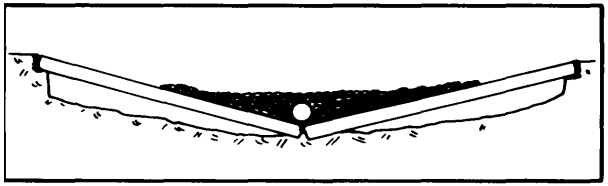


Figure 7-29. Use of sandbags to repair damaged bridge

# Chapter 8
# Roads and Airfields

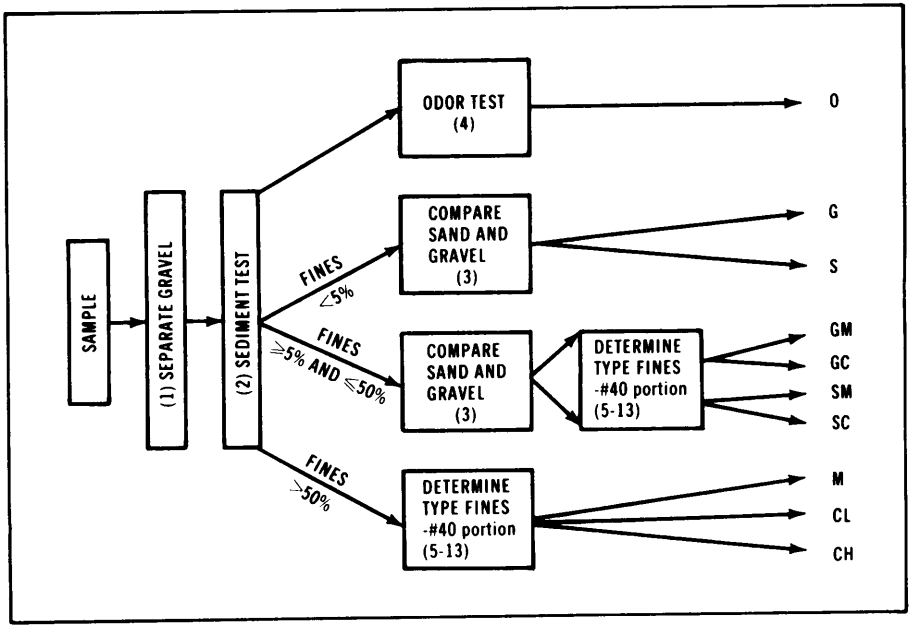
## SOILS

### Characteristics

Table 8-1 shows the characteristics of specific soils. Figure 8-1 outlines steps for field identification of soils.

Table 8-1. Soil characteristics

| SYMBOL | DESCRIPTION | DRAINAGE CHARACTERISTICS | AIRFIELD INDEX (FROST SUSCEPTIBILITY) | VALUE AS A SUBGRADE | VALUE AS A SUBBASE | VALUE AS A BASE | COMPACTION EQUIPMENT |
|---|---|---|---|---|---|---|---|
| G | Gravels and Sandy Gravel with little or no Fines | Excellent | None to very Slight | Good to Excellent | Good to Excellent | Fair to Good | Crawler Tractor. Rubber Tire Roller. Steel Wheel Roller |
| GM | Silty Gravels. Gravel-Sand Silt Mixture | Fair to Practically Impervious | Slight to Medium | Good | Fair to Good | Not Suitable | Rubber Tire Roller. Sheepsfoot Roller |
| GC | Clayey Gravels. Gravel. Sand-Clay Mixtures | Poor to Practically Impervious | Slight to Medium | Good | Fair | Not Suitable | Rubber Tire Roller. Sheepsfoot Roller |
| S | Sands and Gravels. Sands with little or no Fines | Excellent | None to very Slight | Fair to Good | Fair to Good | Not Suitable | Crawler Tractor. Rubber Tire Roller |
| SM | Silty-Sands. Sand-Silt Mixtures | Fair to Practically Impervious | Slight to Medium | Fair to Good | Poor to Fair | Not Suitable | Rubber Tire Roller. Sheepsfoot Roller |
| SC | Clayey Sands. Sand-Clay Mixtures | Poor to Practically Impervious | Slight to High | Poor to Fair | Poor | Not Suitable | Rubber Tire Roller. Sheepsfoot Roller |
| M | Inorganic Silts and very fine Sand Rock Flour. Clayey Silts with slight Plasticity | Fair to Poor | Medium to High | Poor to Fair | Not Suitable | Not Suitable | Rubber Tire Roller. Sheepsfoot Roller |
| CL | Inorganic Clays low to medium Plasticity Gravelly or Sandy Clays | Practically Impervious | Medium to High | Poor to Fair | Not Suitable | Not Suitable | Rubber Tire Roller. Sheepsfoot Roller |
| CH | Inorganic Clays of high Plasticity | Practically Impervious | Medium | Poor to Fair | Not Suitable | Not Suitable | Sheepsfoot Roller |
| O | Mineral Grains containing highly Organic Matter | Poor to Practically Impervious | Medium to High | Poor to Very Poor | Not Suitable | Not Suitable | Rubber Tire Roller. Sheepsfoot Roller |
| PT | Peat and Other highly decomposed Vegetable Matter | Fair to Poor | Slight | Not Suitable | Not Suitable | Not Suitable | Compaction not Practical |




NOTE: This procedure will give a very hasty classification of soils, and SHOULD NOT BE DESIGNED OF PERMANENT OR SEMIPERMANENT CONSTRUCTION.

**Figure 8-1. Field identification of soils**

1. Separate Gravel
   a. Remove from sample all particles larger than ¼" diameter (#4 sieve).
   b. Estimate the percent gravel (G) by volume.
2. Sedimentation Test to determine percent sand (S)
   a. Mason jar method.
      1. Put approximately 1" of sample in glass jar
      2. Mark depth of sample with grease pencil
      3. Fill jar with 5 or 6 inches of clear water. Leave 1 inch of air at top
      4. Shake the mixture vigorously for 3 to 4 minutes
      5. Allow the sample to settle for 30 seconds
      6. Compare sediment line to grease pencil mark estimating percent settled
      7. Determine percent Sand and Fines: 100 - % Gravel = % Sand and Fines
      8. Determine percent Sand: $\frac{\%\ \text{Settled}}{100} \times \%\ \text{Sand and Fines} = \%\ \text{Sand}$
   b. Canteen cup method
      1. Place sample (less gravel) in canteen cup and mark level
      2. Fill with water and shake mixture vigorously
      3. Allow mixture to stand for 30 seconds to settle out
      4. Pour off water
      5. Repeat Steps 2 and 4 until water poured off is clear
      6. Dry the soil left in the cup (Sand)
      7. Estimate percent Sand by comparing the level of sand with mark percent sand = (% sand in cup) (100% - % gravel)
3. Comparison of Gravel, Sand, and Fines
   a. Percent Gravel was estimated in Test 1-Step b
   b. Percent Sand was estimated in Test 2-Step #8
   c. Percent Fines = 100 - % Gravel - % Sand
4. Odor Test
   a. Heat sample with match or open flame
   b. If odor becomes musty or foul smelling, there is a strong indication that organic material is present
5. Dry Strength Test (-#40 sieve)
   a. Form moist pat 2 inches in diameter by ½ inch thick
   b. Allow to dry with low heat
   c. Place dry pat between thumb and index finger only and attempt to break
   d. Breakage easy - Silt (M)
      Breakage difficult - Low compressible Clay (CL)
      Breakage impossible - High compressible Clay (CH)
6. Powder Test
   a. Scrape portion of broken pat with thumbnail and attempt to flake particles off
   b. Pat powders or flakes - Silt (M)
      Pat does not powder or flake - Clay (C)
7. Feel Test
   a. Rub portion of dry soil over a sensitive portion of skin such as inside of wrist
   b. Feel harsh or irritating - Silt (M)
      Feel smooth and floury - Clay (C)
8. Shine Test
   a. Draw smooth surface, such as knife blade or thumbnail, over pat of slightly moist soil
   b. Surface becomes shiny and lighter in texture - Clay (C)
      Surface dull or granular - Silt (M) or Sand (S)
9. Thread Test
   a. Form ball of moist soil (marble size)
   b. Attempt to roll into ⅛ inch diameter thread (wooden match size)
   c. Thread easily obtained - Clay (C)
      Thread cannot be obtained - Silt (M)
10. Ribbon Test
   a. Form cylinder of moist soil, approximately cigar shape and size
   b. Flatten cylinder over index finger with thumb; attempting to form ribbon 8 inches to 9 inches long, ⅛ inch to ¼ inch thick, and 1 inch wide
   c. Ribbon 8 inches or larger obtained - CH
      Ribbon 3 to 8 inches obtained - CL
      Ribbon 0 to 3 inches obtained - M
11. Grit or Bite Test
   a. Place pinch of sample between teeth and bite
   b. Sample feels gritty - Silt (M)
      Sample feels floury - Clay (C)
12. Wet Shaking Test
   a. Place pat of very moist soil (not sticky) in palm of hand
   b. Shake hand vigorously and strike against other hand
   c. Observe rapidity of water rising to the surface
      Fast, positive reaction - Silty (M)
      No (negative) reaction - Clayey (C)
13. Hand Washing Test
   - Easy = Silt (M)
   - Difficult = Clay (C)

Figure 8-1. Field identification of soils (continued)

### Moisture Content

To determine whether or not soil is at or near Optimum Moisture Content (OMC). mold a golf ball size sample of soil with your hands. Squeeze the ball between your thumb and forefinger. If the ball shatters into several fragments of rather uniform size, the soil is near or at OMC. If the soil is difficult to roll into a ball or it crumbles under very little pressure, the soil IS below OMC.

### Stabilization

See Table 8-2 for recommended soil stabilizing agents.

**Table 8-2. Recommended initial stabilizing agent given in percentage by weight**

| SOIL TYPE | HYDRATED LIME | QUICKLIME |
|---|---|---|
| GC. GM-GC | 2-4 | 2-3 |
| CL | 5-10 | 3-8 |
| CH | 3-8 | 3-6 |

| SOIL TYPE | PORTLAND CEMENT |
|---|---|
| GW. SW | 3-5 |
| GP. GM. SM | 5-8 |
| GC. SC | 5-9 |
| SP | 7-11 |
| CL. ML | 8-13 |
| CH | 9-15 |
| MH. OH | 10-16 |

## DRAINAGE

The most common drainage structures are open ditches and culverts.

### Runoff Estimates

The volume of water that is to be carried by the open channel or culvert can be estimated as follows:

**Cross-sectional area estimate**

Compute the amount of water that has been carried by the open channel (Figure 8-2). Continue with the culvert or the open ditch design on page 8-6.

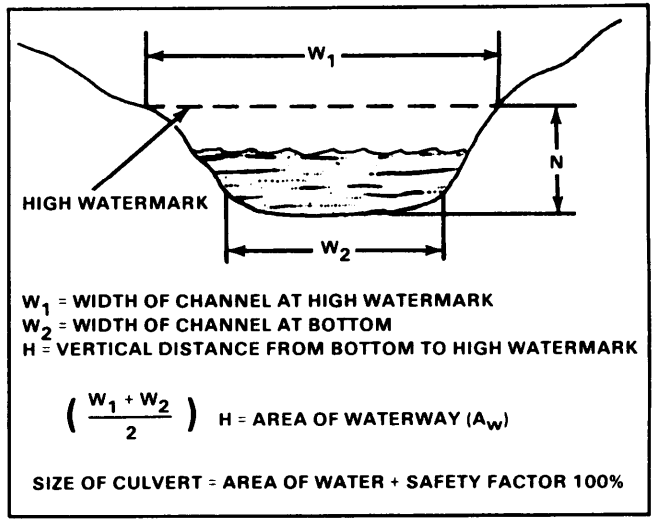



**Figure 8-2. Cross-sectional area of water**

**Runoff field estimate method (Q = 2ARC)**

Determine acreage contributing runoff to project area by delineating drainage areas and drawing flow lines (If drainage areas exceed 100 acres, do not use this method ) Remember that water flows down hill and perpendicular to contour lines. Calculate total contributing area in acres (1 acre = 43,560 $ft^2$= 4.047$M^2$). Find your general location on Figure 8-3 and select the appropriate rainstorm intensity If your location is between two lines, select the higher value Select runoff coefficient from Table 8-3 and determine expected flow by using formula:

Q = 2ARC

Where Q = total runoff m CFS
A = drainage area in acres
R = rainfall intensity (Figure 8-3)
C = coefficient factor (Table 8-3)

Compute (cross-sectional area of water) using formula: $A_w = \frac{Q}{V}$

Where = cross-sectional area in
Q = quantny of water in CFS
V = water velocity (If not known, use 4.)

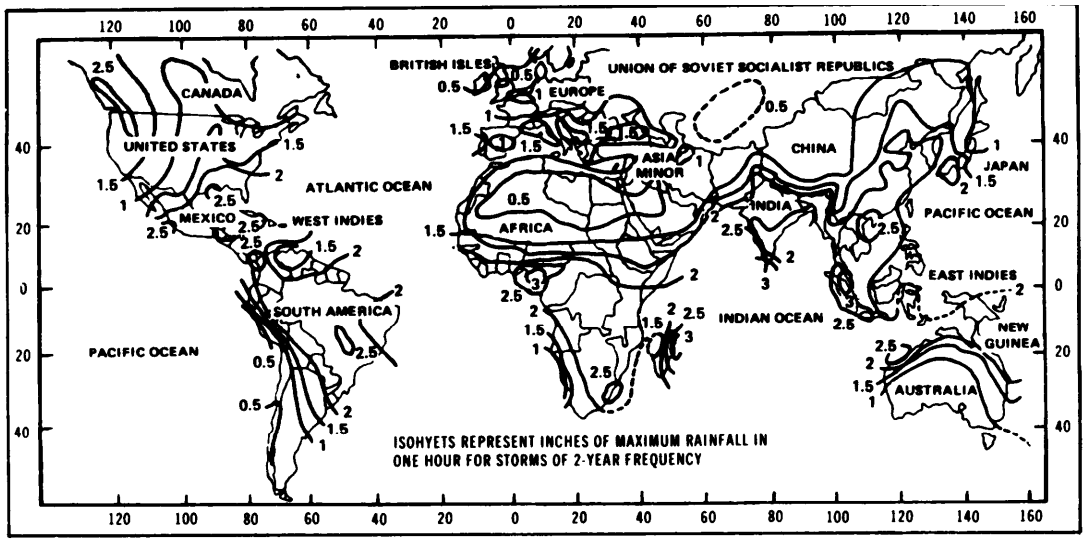



**Figure 8-3. World Isohyetal map**

Table 8-3. Runoff coefficient

| MAJOR DIVISIONS | | LETTER | | DRAINAGE CHARACTERISTICS | WITH TURF | WITH-OUT TURF |
|---|---|---|---|---|---|---|
| Coarse-Grained Soils | Gravel and Gravelly Soils | GW | | Pervious | .10 | .20 |
| | | GP | | Pervious | .10 | .20 |
| | | GM | d | Slightly Pervious | .30 | .40 |
| | | | u | Impervious | .55 | .65 |
| | | GC | | Impervious | .55 | .65 |
| | Sand and Sandy Soils | SW | | Pervious | .10 | .20 |
| | | SP | | Pervious | .10 | .20 |
| | | SM | d | Slightly Pervious | .30 | .40 |
| | | | u | Impervious | .55 | .65 |
| | | SC | | Impervious | .55 | .65 |
| Fine-Grained Soils | Silts and Clays LL < 50 | ML | | Slightly Pervious | .30 | .40 |
| | | CL | | Impervious | .55 | .65 |
| | | OL | | Impervious | .55 | .65 |
| | Silts and Clays LL ≥ 50 | MH | | Slightly Pervious | .30 | .40 |
| | | CH | | Impervious | .55 | .65 |
| | | OH | | Impervious | .55 | .65 |
| Highly Organic Soils | | $P_t$ | | Slightly Pervious | .30 | .40 |
| | Asphalt pavements, roof surfaces | | | | | .95 |
| | Concrete pavements | | | | | .90 |
| | Gravel or macadam pavements | | | | | .70 |
| Wooded Areas | | | | | | .20 |

## Culverts

### Design

Using previously obtained area of water ($A_w$), the culvert design area ($A_{des}$) is $2A_w$. See Figure 8-4 to determine the maximum allowabe culvert diameter, fall, and cover Round DOWN to next available culvert diameter. Determine number of pipes using formula:

$$N = \frac{2A_w}{\text{pipe area}} = \frac{A_{des}}{\text{pipe area}}$$

Start working with the largest available culvert that meets the maximum diameter requirement. Then go to smaller diameters until the most economical solution is found.

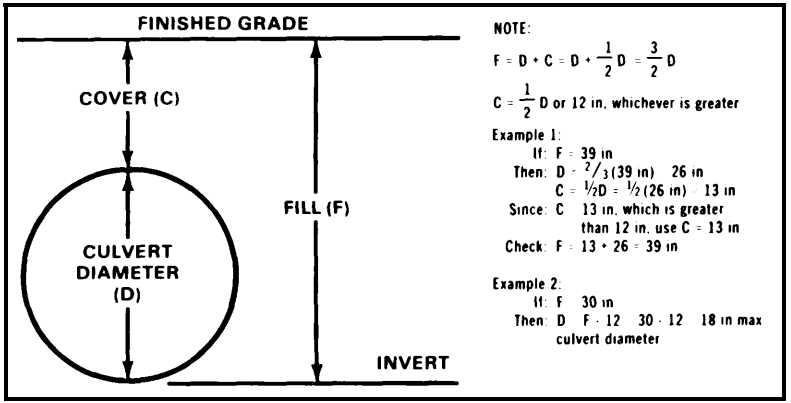



Figure 8-4. Minimum fill and cover

## Length

Figure 8-5. shows length determination procedures

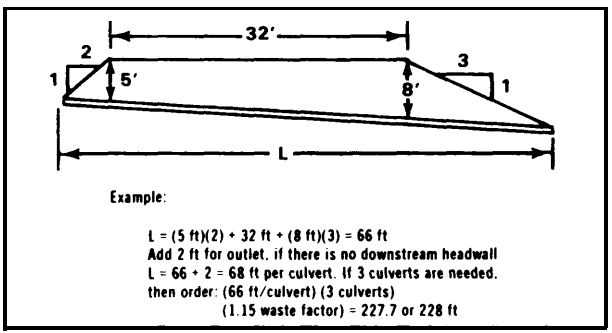



Figure 8-5. Culvert length determination

## Installation

During installation, the following criteria should be adhered to whenever possible:

- Place the inlet elevation at or below the ditch bottom.
- Extend the culvert 2 feet minimum downstream beyond the fill slopes.
- Use bedding of D/10 minimum.
- Space multiple culverts a minimum of D/2 apart.
- Desired slope is 2 to 4 percent, minimum slope is 0.5 percent.
- Always use a headwall upstream.
- Riprap downstream to control erosion.

**Examples**

Examples of field expedient culverts are shown in Figure 8-6.

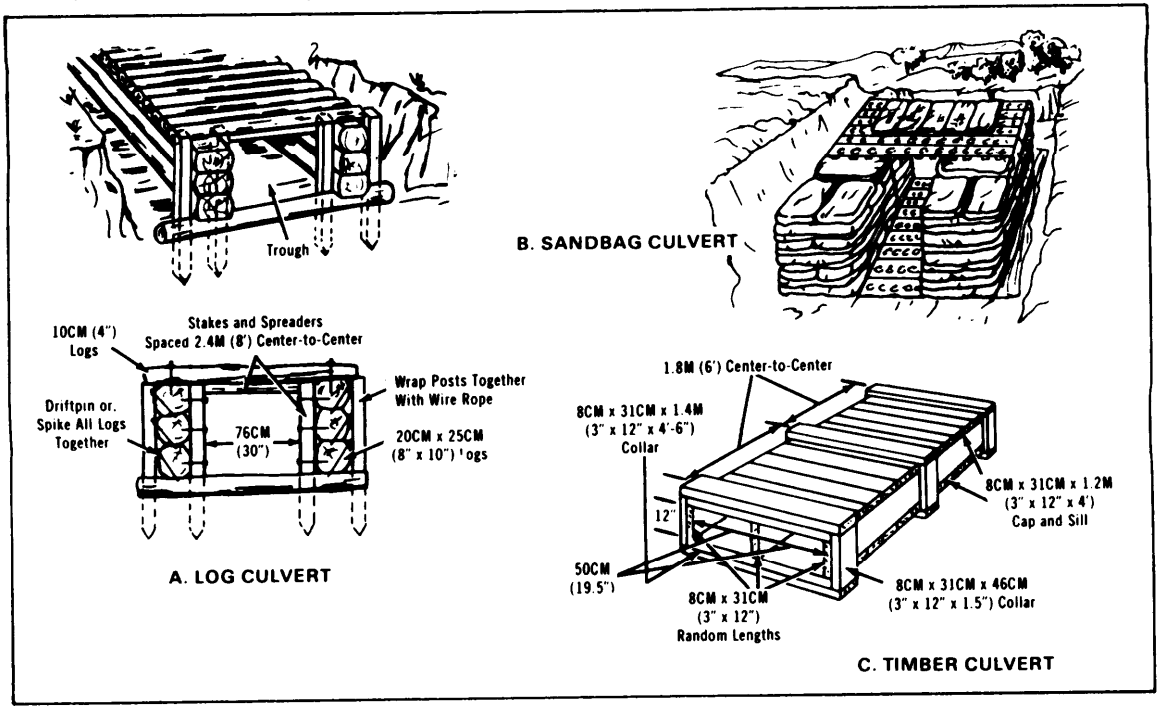



**Figure 8-6. Expedient culvert examples**

## Open Ditch Design

- Determine area of water ($A_w$) using formula (page 8-4):

$$A_w = \frac{Q}{V}$$

- Select site slope ratio based on soil stability (Table 8-4), equipment capacity, and safety.

- Determine cutting depth IAW Figure 8-7.

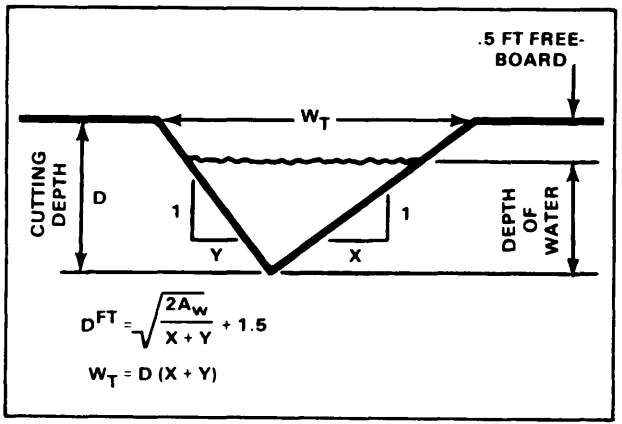



**Figure 8-7. Open ditch**

**Table 8-4. Recommended requirements for slope ratios in cuts and fills: homogeneous soils**

| USCS CLASSIFICATION | SLOPES NOT SUBJECT TO SATURATION | | SLOPES SUBJECT TO SATURATION | |
|---|---|---|---|---|
| | MAX HT OF EARTH FACE | MAXIMUM SLOPE RATIO | MAX HT OF EARTH FACE | MAXIMUM SLOPE RATIO |
| GW, GP, GMd SW, SP, SMd | Not Critical | 1½:1 | Not Critical | 2:1 |
| GMu, GC SMu, SC ML, MH CL, CH | Less Than 50 Feet | 2:1 | Less Than 50 Feet | 3:1 |
| OL, OH, Pt | Generally not suitable for construction | | | |

NOTES: 1. Recommended slopes are valid only in homogeneous soils that have either an in-place or compacted density equaling or exceeding 95 percent CE55 maximum dry density. For nonhomogeneous soils, or soils at lower densities, a deliberate slope stability analysis is required.

2. Backslopes cut in to loess soil will seek to maintain a near-vertical cleavage. DO NOT apply loading above this cut face. Expect sloughing to occur.

## EXPEDIENT PAVEMENTS

### Expedient Road Surfaces

See Chapter 2 (pages 2-19 through 2-22).

### Expedient Airfield Surfaces

Calculate requirements using Table 8-5 and Table 2-11 (page 2-24) to prepare subgrade, lay membrane. and lay matting.

**Table 8-5. Mat characteristics**

| | M8A1 | M8 | M18b | M19 | AM2 |
|---|---|---|---|---|---|
| **Bundle** | | | | | |
| Volume ($ft^3$) | 24.7 | 22.7 | 74 | 85.7 | 62 |
| Placing area ($ft^2$) | 269 | 269 | 432 | 534 | 288 |
| Weight | 2.036 | 1.960 | 2.400 | 2.484 | 1.980 |
| **Number of panels (Full/Half)** | 13/2 | 13/2 | 16/4 | 32/0 | 11/2 |
| **Panel** | | | | | |
| Dimension (ft) | 1.6x11.8 | 1.6x11.8 | 2x12 | 4x4.1 | 2x12 |
| Weigh (lb) | 144 | 140 | 120 | 68 | 140 |
| Placing area ($ft^2$) | 19.2 | 19.2 | 24 | 16.7 | 24 |

Start placing matting from one corner of runway with male hinges parallel with and toward centerline. The first strip must be laid along edge of roadway. The second strip must be staggered so that the connectors from the first strip are at the center of the second strip panels. Connecting bars MUST be fully inserted (Figure 8-8).

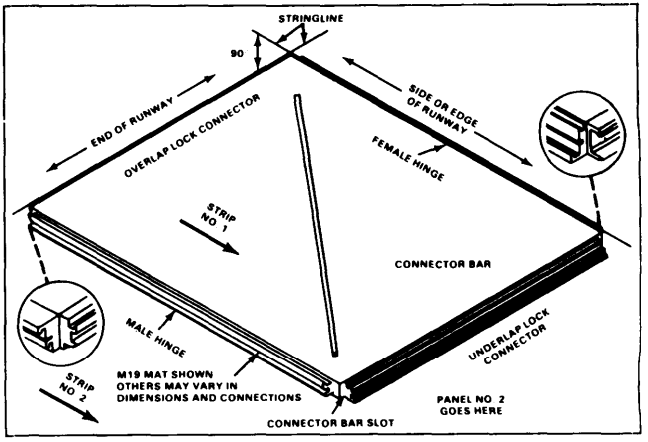



**Figure 8-8. Typical mat and connectors**

## AIRFIELD REPAIR

### Minimum Operating Strip (MOS)

The main focus is the MOS which is 15 meters x 1,525 meters (50 feet x 5,000 feet) for fighter aircraft and 26 meters x 2,134 meters (90 feet x 7,000 feet) for cargo.

### Priority of Work

See Figure 8-9.

(1) Establish first MOS (15M x 1.525M/50' x 5,000').
(2) Use minimal effort to build 7.6M (25') wide access routes.
(3) Establish second MOS (15M x 1.525M/50' x 5,000').
(4) Build more 7.6M (25') wide access routes
(5) Lengthen first MOS to 2.134M (7,000')
(6) Lengthen second MOS to 2.134 M (7.000')
(7) Widen first MOS 27.4M (90')
(8) Widen second MOS to 27.4M (90')

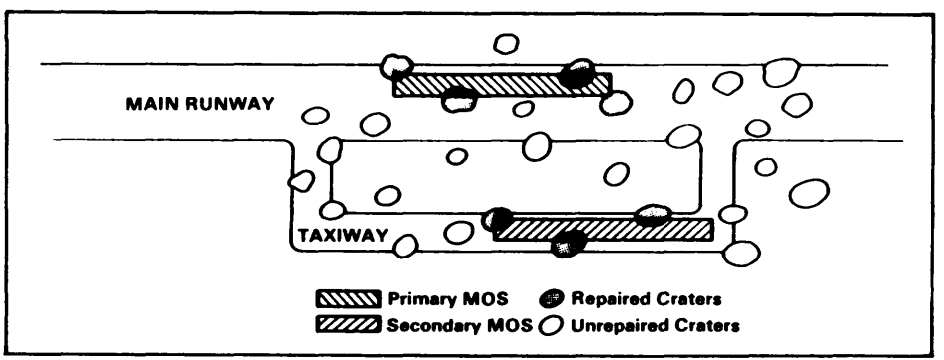



**Figure 8-9. Airfield repair priority of work**

## Membrane and Mat Repair

### Membranes

Repair tears in membranes by cutting an "X" and lifting the four flaps back. Place a new peice of membrane under the torn area to extend at least 30 centimeters (12 inches) beyond the torn area. Apply an adhesive to top of new membrane and bottom of old membrane. Allow adhesive to become tacky. Fold flaps back into position and allow adhesive to set for at least 15 minutes. Roll patched area with a wheeled roller or vehicle.

### Mats

**M8A1.** Unlock end connector bars from damaged panel and remove locking lugs. Move panel laterally until hooks are centered on slots. Pry hooks out of slots and move panel to clear overlapping ends. Remove damaged panel. Remove locking lugs from new panel and orient to same position as damaged panel. Reverse removal procedures.

**AM2.**

*Slide out method.* Slide out entire run where damage to panel is located. Remove end connector bars. Replace damaged panel. Push new run in until it is 5 to 10 centimeters (2 to 4 inches) from next panel, and continue procedure until all panels have been replaced. Push run to its original position.

*Cutting method.* If special repair panels are available, cut the damaged panel as shown in Figure 8-10 and remove pieces Replace with special repair panel and accessories (Figure 8-11 ).

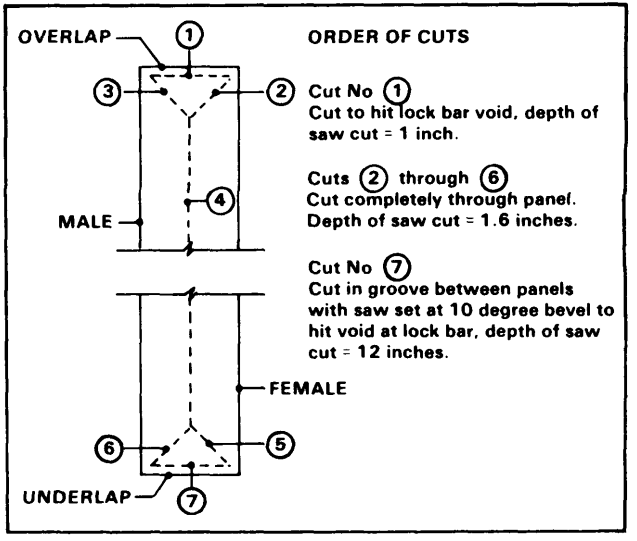



Figure 8-10. AM2 mat cutting method

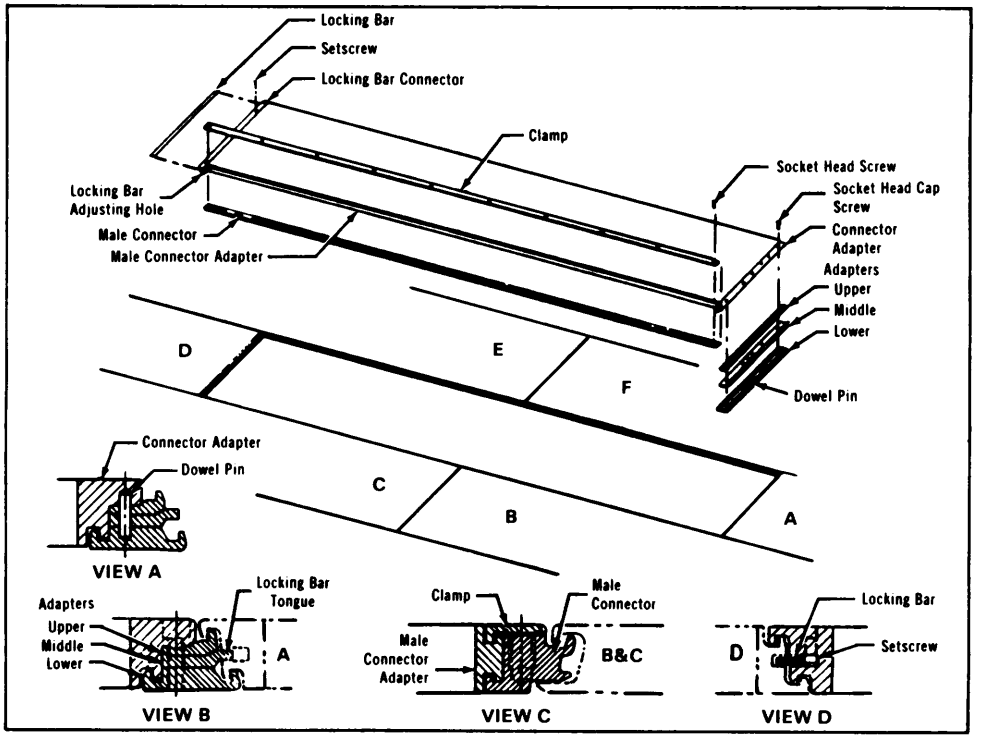



Figure 8-11. AM2 special repair panel

**M19.** Replace a single mat by using a clrcular saw and cut as shown in Figure 8-12. Use pry-bar and lift cut pieces. Unbolt edges of damaged panel and replace as shown in Figure 8-13.

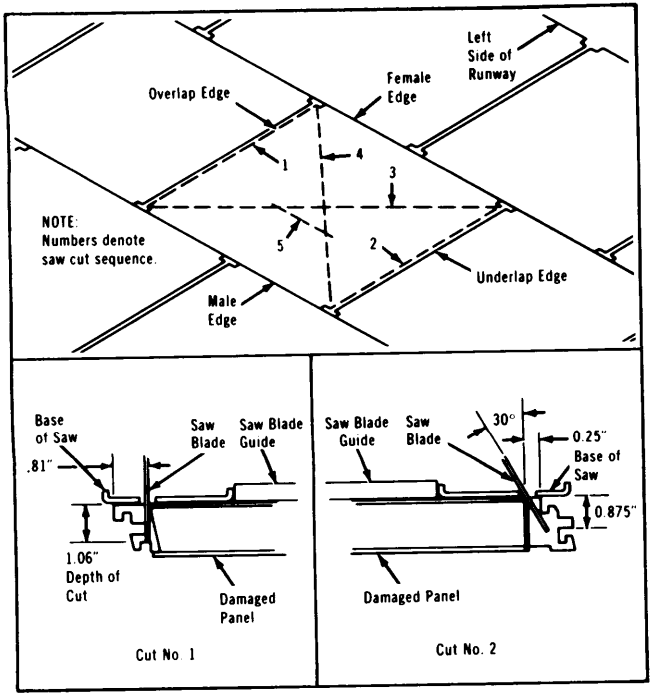



Figure 8-12. Cutting of M19 mat

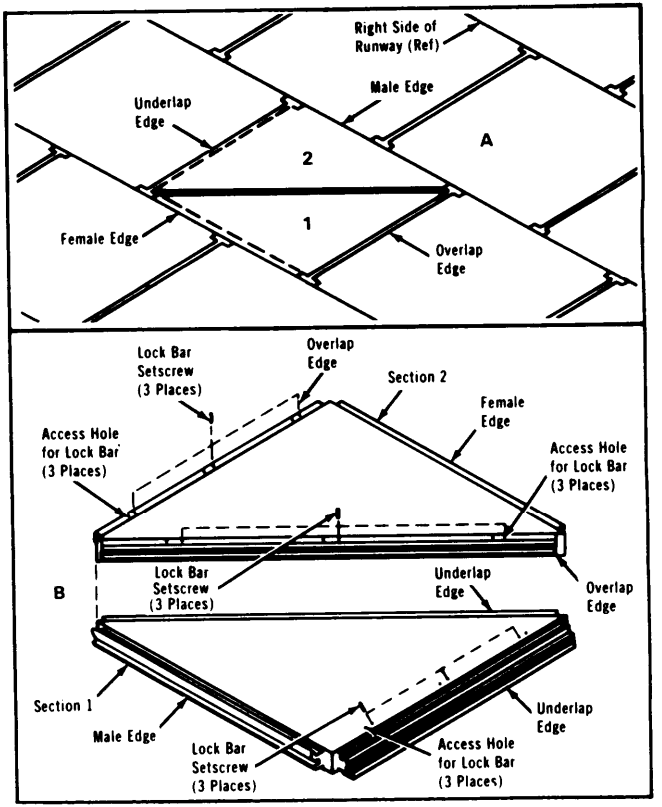



Figure 8-13. M29 repair panel replacement

For repair of large areas, create a pyramid as shown in Figure 8-14. Remove maintenance access adapter and start removing panel from the outside in until reaching the damaged area. Replace the damaged area and removed panels.

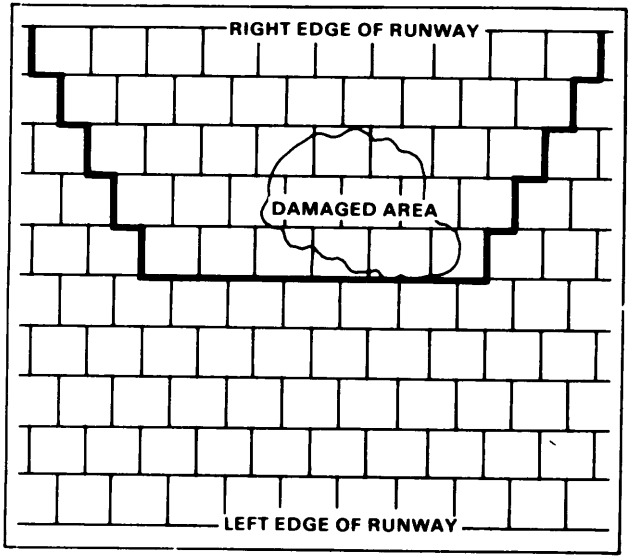



Figure 8-14. Repair of M19 large damaged areas

**Other Than Membrane and Mat Surface Repairs**

Figures 8-15 through 8-17 show different emergency repair methods.

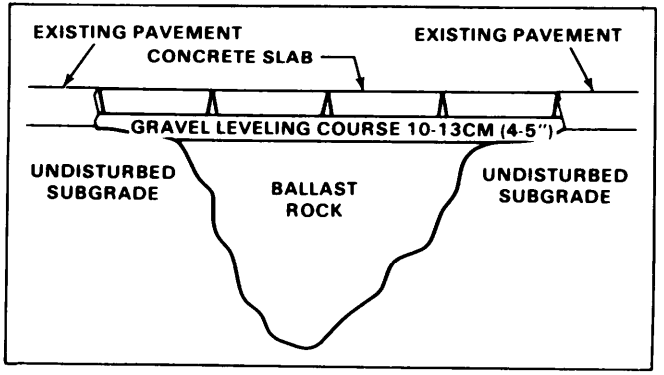



Figure 8-15. Precast concrete slab crater repair

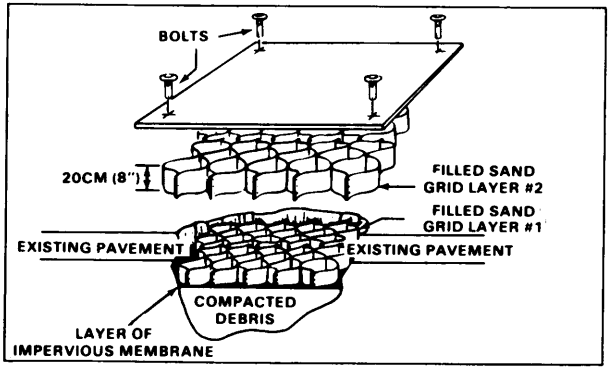
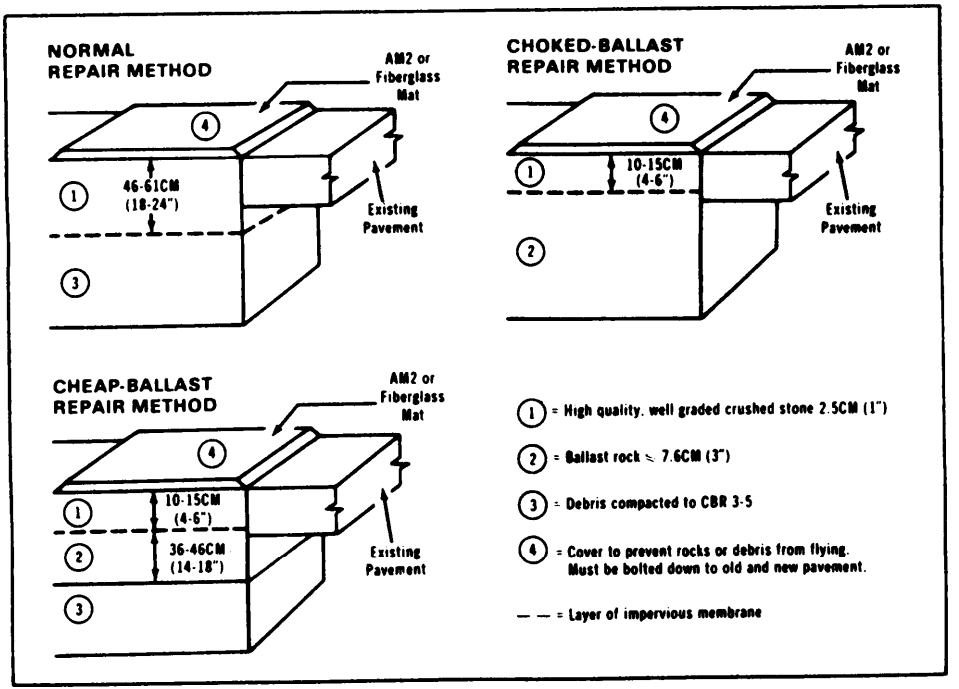



Figure 8-16. Sand grid repair method


NORMAL
REPAIR METHOD
AM2 or
Fiberglass
Mat
4
1
46-61CM
(18-24")
3
Existing
Pavement
CHOKED-BALLAST
REPAIR METHOD
AM2 or
Fiberglass
Mat
4
1
10-15CM
(4-6")
2
Existing
Pavement
CHEAP-BALLAST
REPAIR METHOD
AM2 or
Fiberglass
Mat
4
1
10-15CM
(4-6")
2
36-46CM
(14-18")
3
Existing
Pavement
1 = High quality, well graded crushed stone 2.5CM (1")
2 = Ballast rock ≤ 7.6CM (3")
3 = Debris compacted to CBR 3-5
4 = Cover to prevent rocks or debris from flying.
Must be bolted down to old and new pavement.
— — = Layer of impervious membrane

# Chapter 9
# Rigging and Vehicle Recovery

## ROPES

Tables 9-1 and 9-2 give characteristics, safety factors, and breaking strength for different diameters of wire, manila, and sisal ropes.

**Table 9-1. Wire rope characteristics and safety factors**

| BREAKING STRENGTH OF 6 x 19 STANDARD WIRE ROPE [2] | | | | | | |
|---|---|---|---|---|---|---|
| | | | BREAKING STRENGTH, TONS OF 2,000 LB | | | |
| DIAMETER [3] IN | APPROXIMATE WEIGHT LB/FT | IRON | TRACTION STEEL | PLOUGH STEEL | IMPROVED PLOUGH STEEL | EXTRA IMPROVED PLOUGH STEEL |
| ¼ | 0.10 | 1.4 | 2.6 | 2.39 | 2.74 | |
| ⅜ | 0.23 | 2.1 | 4.0 | 5.31 | 6.10 | 7.55 |
| ½ | 0.40 | 3.6 | 6.8 | 9.35 | 10.7 | 13.3 |
| ⅝ | 0.63 | 5.5 | 10.4 | 14.5 | 16.7 | 20.6 |
| ¾ | 0.90 | 7.9 | 14.8 | 20.7 | 23.8 | 29.4 |
| ⅞ | 1.23 | 10.6 | 20.2 | 28.0 | 32.2 | 39.8 |
| 1 | 1.60 | 13.7 | 26.0 | 36.4 | 41.8 | 51.7 |
| 1 ⅛ | 2.03 | 17.2 | 32.7 | 45.7 | 52.6 | 65.0 |
| 1 ¼ | 2.50 | 21.0 | 40.6 | 56.2 | 64.6 | 79.9 |
| 1 ½ | 3.60 | 29.7 | 56.6 | 80.0 | 92.0 | 114.0 |
| 1 ¾ | | | | 108.0 | 124.0 | 153.0 |
| 2 | | | | 139.0 | 160.0 | 198.0 |

| SAFETY FACTORS [1] | |
|---|---|
| TYPE OF SERVICE | MINIMUM SAFETY FACTOR |
| Track cables | 3.2 |
| Guy lines | 3.5 |
| Miscellaneous hoisting equipment | 5.0 |
| Haulage ropes | 6.0 |
| Derricks | 6.0 |
| Small electric and air hoists | 7.0 |
| Slings | 8.0 |

**NOTES:** 1. If age and condition of rope are doubtful and human life or equipment may be endangered, apply a safety factor of at least eight.

2. The 6 x 19 means rope composed of 6 strands of 19 wires each.

3. Breaking strength of 6 x 7 or 6 x 37 wire ropes is 94 percent of the breaking strengh of a 6 x 19 rope of an equal diameter and identical material.

Example:

Find breaking strength of 1 ¼ inch, 6 x 7. Improved Plough Steel wire rope

Breaking strength of 6 x 19. 1 ¼ inch. Improved Plugh Steel wire rope = 64.6 tons

Breaking strength (6 x 7) = .94 x 64.6 = 60.7 tons

Table 9-2. Properties of sisal and manila ropes

| NOMINAL DIAMETER, IN | CIRCUMFERENCE, IN | LB PER FT | NO. 1 MANILA | | SISAL | |
|---|---|---|---|---|---|---|
| | | | BREAKING STRENGTH, TONS | SAFE WORKING CAPACITY, TONS (F.S. = 4) | BREAKING STRENGTH, TONS | SAFE LOAD, TONS (F.S. = 4) |
| 1/4 | 3/4 | 0.20 | 0.30 | 0.07 | 0.24 | 0.06 |
| 3/8 | 1 1/8 | .040 | 0.67 | 0.16 | 0.54 | 0.13 |
| 1/2 | 1 1/2 | .075 | 1.32 | 0.33 | 1.06 | 0.26 |
| 5/8 | 2 | .133 | 2.20 | 0.60 | 1.76 | 0.44 |
| 3/4 | 2 1/4 | .167 | 2.70 | 0.67 | 2.16 | 0.54 |
| 7/8 | 2 3/4 | .186 | 3.85 | 0.96 | 3.08 | 0.77 |
| 1 | 3 | .270 | 4.50 | 1.12 | 3.60 | 0.90 |
| 1 1/8 | 3 1/2 | .360 | 6.00 | 1.50 | 4.80 | 1.20 |
| 1 1/4 | 3 3/4 | .418 | 6.75 | 1.69 | 5.40 | 1.35 |
| 1 1/2 | 4 1/2 | .600 | 9.25 | 2.31 | 7.40 | 1.85 |
| 1 3/4 | 5 1/2 | .895 | 13.25 | 3.31 | 10.60 | 2.65 |
| 2 | 6 | 1.08 | 15.50 | 3.87 | 12.40 | 3.10 |
| 2 1/2 | 7 1/2 | 1.35 | 23.25 | 5.81 | 18.60 | 4.65 |
| 3 | 9 | 2.42 | 32.00 | 8.00 | 25.60 | 6.40 |

**NOTES:** 1. Breaking strength and safe loads given are for new rope used under favorable conditions. As rope ages or deteriorates, progressively reduce safe loads to one-half of values given.

2. Safe working capacity maybe computed, with safety factor of 4. When condition of material is doubtful, divide computation by 2.

$$T = D^2$$

where, T = safe working capacity In tons

D = diameter in inches

3. Cordage rope is issued by circumference sizes.

## CHAINS AND HOOKS

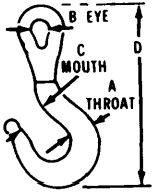
Table 9-3. Safe working load of chains (SF=6)

| SIZE | APPROXIMATE WEIGHT PER LINEAR FOOT IN POUNDS | SAFE WORKING LOAD IN POUNDS | | | |
|---|---|---|---|---|---|
| | | COMMON IRON | HIGH GRADE IRON | SOFT STEEL | SPECIAL STEEL |
| 1/4 | 0.8 | 512 | 563 | 619 | 1.240 |
| 3/8 | 1.7 | 1.350 | 1.490 | 1.650 | 3.200 |
| 1/2 | 2.5 | 2.250 | 2.480 | 2.630 | 5.250 |
| 5/8 | 4.3 | 3.470 | 3.810 | 4.230 | 7.600 |
| 3/4 | 5.8 | 5.070 | 5.580 | 6.000 | 10.500 |
| 7/8 | 8.0 | 7.000 | 7.700 | 8.250 | 14.330 |
| 1 | 10.7 | 9.300 | 10.230 | 10.600 | 18.200 |
| 1 1/8 | 12.5 | 9.871 | 10.858 | 11.944 | 21.500 |
| 1 1/4 | 16.0 | 12.186 | 13.304 | 14.634 | 26.300 |
| 1 3/8 | 18.3 | 14.717 | 16.188 | 17.807 | 32.051 |

**NOTE:** Size is the diameter in inches of one side of a link.

Table 9-4. Safe load on hooks

| DIAMETER OF METAL A, IN | INSIDE DIAMETER OF EYE B, IN | WIDTH OF OPENING C, IN | LENGTH OF HOOK D, IN | SAFE WORKING CAPACITY OF HOOKS, LB |
|---|---|---|---|---|
| 11/16 | 7/8 | 1 1/16 | 4 15/16 | 1.200 |
| 3/4 | 1 | 1 1/8 | 5 13/32 | 1.400 |
| 7/8 | 1 1/8 | 1 1/4 | 6 1/4 | 2.400 |
| 1 | 1 1/4 | 1 3/8 | 6 7/8 | 3.400 |
| 1 1/8 | 1 3/8 | 1 1/2 | 7 5/8 | 4.200 |
| 1 1/4 | 1 1/2 | 1 11/16 | 8 19/32 | 5.000 |
| 1 3/8 | 1 5/8 | 1 7/8 | 9 1/2 | 6.000 |
| 1 1/2 | 1 3/4 | 2 1/16 | 10 11/32 | 8.000 |
| 1 5/8 | 2 | 2 1/4 | 11 27/32 | 9.400 |
| 1 7/8 | 2 3/8 | 2 1/2 | 13 9/32 | 11.000 |
| 2 1/4 | 2 3/4 | 3 | 14 13/16 | 13.600 |
| 2 5/8 | 3 1/8 | 3 3/8 | 16 1/2 | 17.000 |
| 3 | 3 1/2 | 4 | 19 3/4 | 24.000 |




**NOTE:** Formula for safe work load for hooks:
T (Tons) = $D^2$ ($in^2$).

## SPRUCE TIMBERS

Approximate weight of timber is 40 pounds per cubic foot. See Table 9-5 for safe capacity

**Table 9-5 Safe capacity of spruce timber as gin poles**

| SIZE OF TIMBER, IN | SAFE CAPACITY FOR GIVEN LENGTH OF TIMBER, LB | | | | | |
|---|---|---|---|---|---|---|
| | 6M (20 ft) | 7.5M (25 ft) | 9M (30 ft) | 12M (40 ft) | 15M (50 ft) | 18M (60 ft) |
| 6 dia | 5,000 | 3,000 | 2,000 | | | |
| 8 dia | | 11,000 | 8,000 | 5,000 | 3,000 | |
| 10 dia | 31,000 | 24,000 | 16,000 | 9,000 | 6,000 | |
| 12 dia | | | 31,000 | 19,000 | 12,000 | 9,000 |
| 6 x 6 | 6,000 | 4,000 | 3,000 | | | |
| 8 x 8 | | 14,000 | 10,000 | 6,000 | 4,000 | |
| 10 x 10 | 40,000 | 30,000 | 20,000 | 12,000 | 8,000 | |
| 12 x 12 | | | 40,000 | 24,000 | 16,000 | 12,000 |

NOTE: Safe capacity of each leg of shears or tripod is seven-eights of the value given for a gin pole.

## KNOTS, LASHINGS, AND FASTENINGS

### Knots

The most commonly used knots are shown in Figure 9-1.

| NAME | ILLUSTRATION | USE |
|---|---|---|
| SQUARE | | Join two ropes of same size. (Will not slip, but will draw tight under strain.) To end block lashing. |
| DOUBLE SHEET BEND | | Join wet ropes, of unequal size, or rope to an eye. (Will not slip or draw tight under strain.) |
| BOWLINE | | Form a loop. (Will not slip under strain and is easily untied.) Must be completed with a half-hitch. |
| TIMBER HITCH | | Lifting or dragging heavy timbers. (Is more easily controlled if supplemented by half-hitches.) |
| CLOVE HITCH | | Fasten rope to pipe, timber, or post. (It is used to start and finish all lashings and may be tied at any point in rope.) |
| SHEEP SHANK | | Shorten rope or take load off wear spot of rope. |
| FISHERMAN'S BEND | | To fasten cable or rope to anchor. |

**Figure 9-1. Common knots**

## Lashings

Figures 9-2 through 9-4 show different types of lashings and splicings.

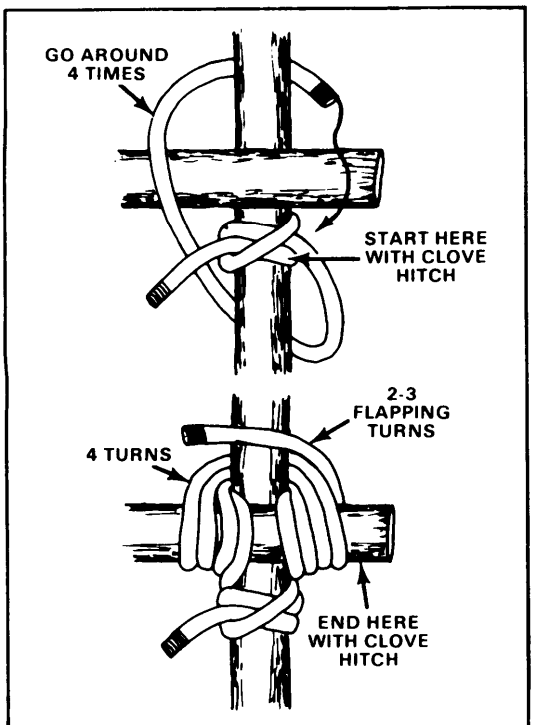



Figure 9-2. Square lashing

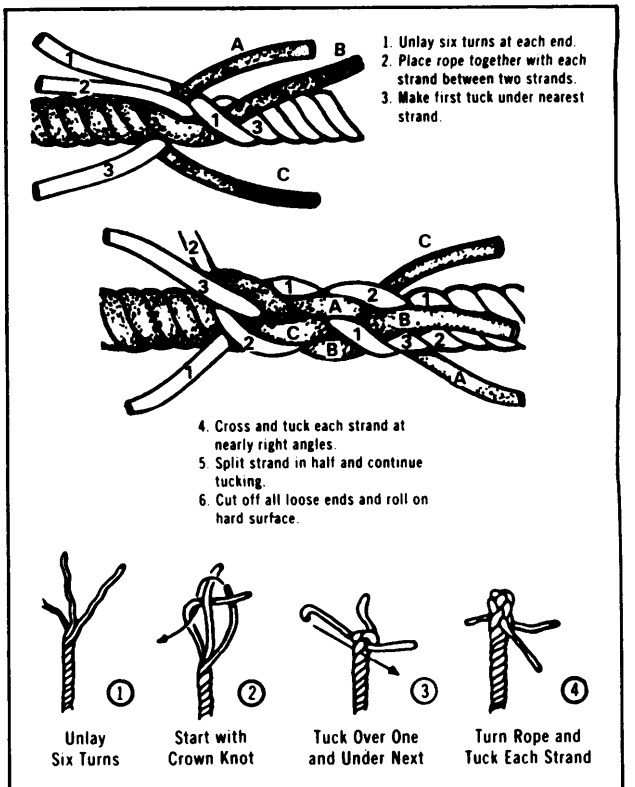



Figure 9-3. Rope splices

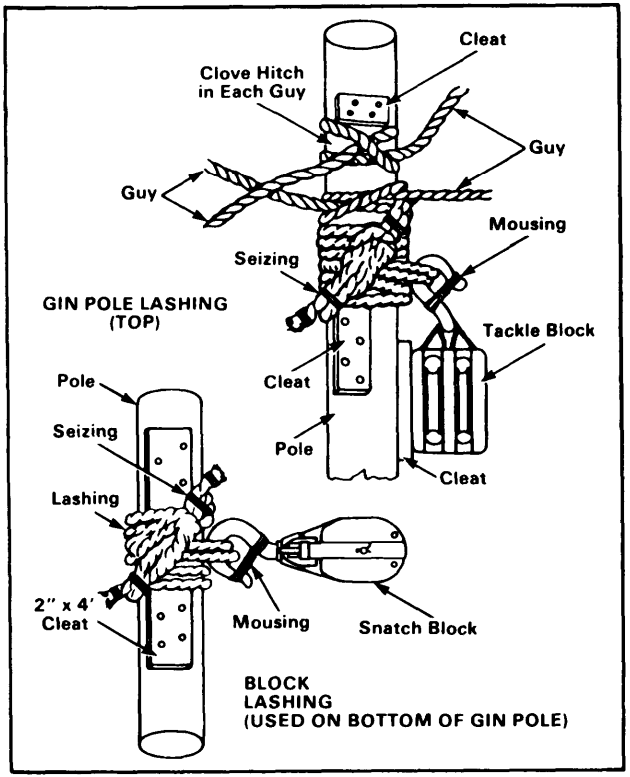



Figure 9-4. Shear, block, and gin pole lashing

## Fastenings

See Table 9-6 for characteristics and usage.

Table 9-6. Wire rope clip

| WIRE ROPE DIAMETER MM (IN) | NOMINAL SIZE OF CLIPS (IN) | NUMBER OF CLIPS | SPACING OF CLIPS MM (IN) | TORQUE TO BE APPLIED TO NUTS OF CLIPS M-KG x 0.1382 (FT-LB) |
|---|---|---|---|---|
| 7.95 (5/16) | 3/8 | 3 | 50 (2) | 3.5 (25) |
| 9.52 (3/8) | 3/8 | 3 | 57 (2 1/4) | 3.5 (25) |
| 11.11 (7/16) | 1/2 | 4 | 70 (2 3/4) | 5.5 (40) |
| 12.70 (1/2) | 1/2 | 4 | 76 (3) | 5.5 (40) |
| 15.85 (5/8) | 5/8 | 4 | 95 (3 3/4) | 9.0 (65) |
| 19.05 (3/4) | 3/4 | 4 | 114 (4 1/2) | 14 (100) |
| 22.22 (7/8) | 1 | 5 | 133 (5 1/4) | 23 (165) |
| 25.40 (1) | 1 | 5 | 152 (6) | 23 (165) |
| 31.75 (1 1/4) | 1 1/4 | 5 | 190 (7 1/2) | 35 (250) |
| 34.92 (1 3/8) | 1 1/2 | 6 | 210 (8 1/4) | 52 (375) |
| 38.10 (1 1/2) | 1 1/2 | 6 | 230 (9) | 52 (375) |
| 44.45 (1 3/4) | 1 3/4 | 6 | 267 (10 1/2) | 78 (560) |

**NOTE.** The spacing of clips should be six times the diameter of the wire rope. To assemble end-to-end connection, the number of clips indicated above should be increased by two. The proper torque indicated above should be used on all clips: U-bolts are reversed at the center of connection so that the U-bolts are on the dead (reduced load) end of each wire rope.

## Slings

For different types of slings, see Figure 9-5.

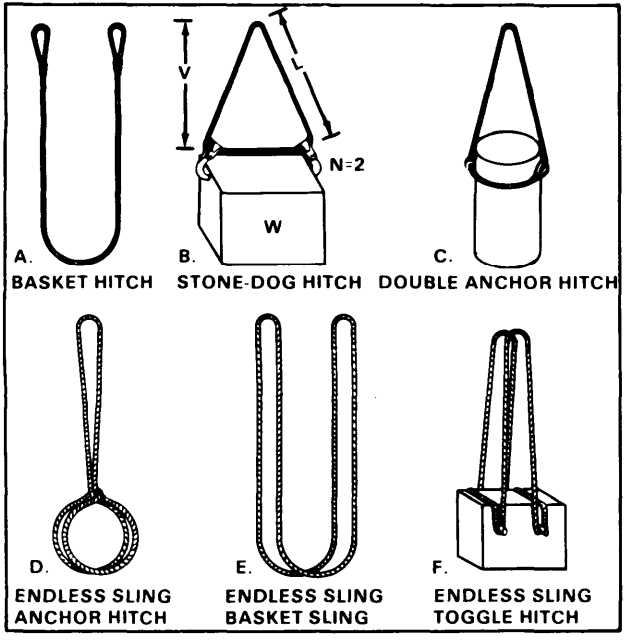



**Figure 9-5. Single, combination, and endless slings**

To determine the sling capacity, use the formula:

$$T = \frac{W}{N} \times \frac{L}{V}$$

Where: T = tension, in pounds
N = number of legs
W = weight of load in pounds
V = vertical distance, in feet
L = length of leg, in feet

} See Figure 9-5.

Example problem. You have a ¾-inch-diameter manila rope. Is it safe to use the rope to lift a 2,000-pound load wiht a 4-leg sling which has a vertical distance of 6 feet and length of leg of 12 feet?

$$T = \frac{W}{N} \times \frac{L}{V}$$

$$T = \frac{2{,}000}{4} \times \frac{12}{6} = 1{,}000 \text{ pounds}$$

The tension on each leg will be 1,000 pounds. The safe working capacity of ¾ - inch-diameter manila rope from Table 9-2 is 0.67 tons or 1.340 pounds. Since the safe working capacity is greater than the tension, the rope is safe to use.

**Hoisting**

Figures 9-6 through 9-8 show expedient lifting devices and their design.

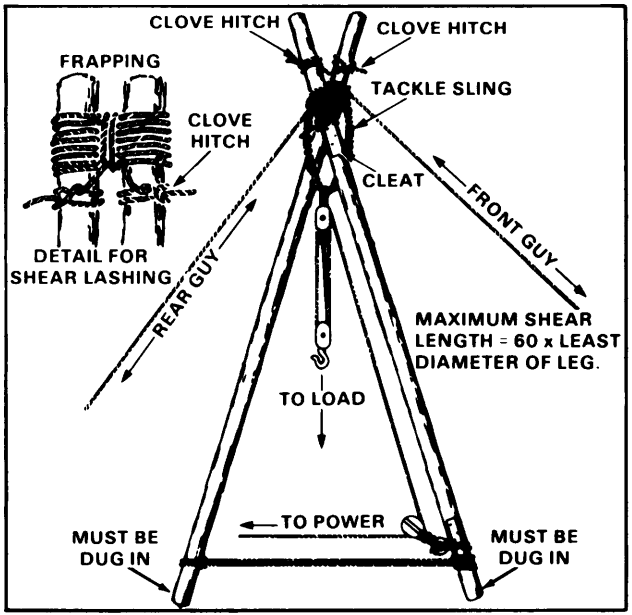



Figure 9-6. Lashing for shears

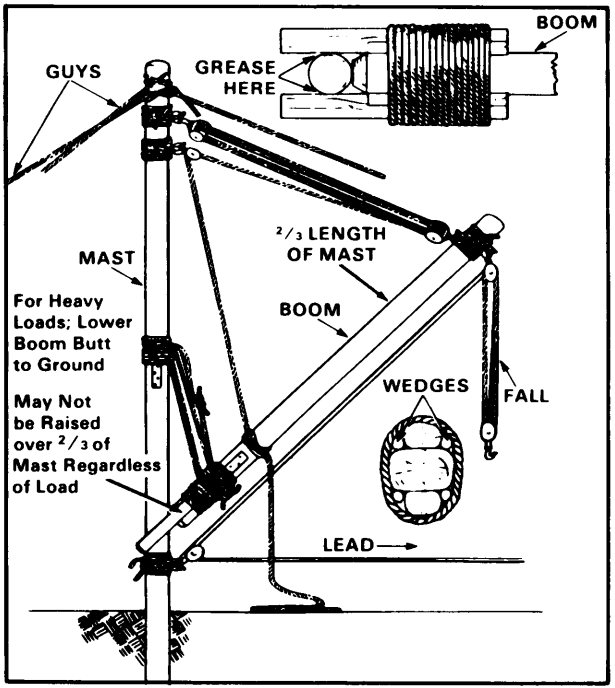



Figure 9-7. Boom derrick

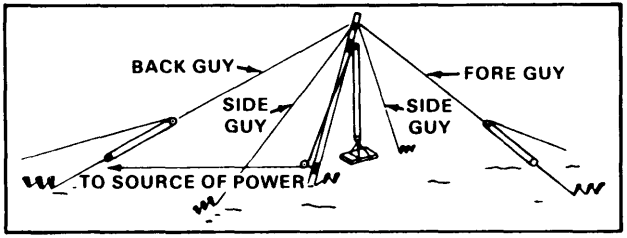



Figure 9-8 Gin pole ready for operation

NOTE: 1. A gin pole 30 to 40 feet may be raised by hand.
2. Maximum length of pole is 60 times minimum diameter.
3. Guys are three to four times the pole length.
4. Refer to Figure 9-4 (page 9-5) for lashing details.

### Tackle Systems

Figure 9-9 shows examples of different tackle systems in a simple tackle system, the mechanical advantage is equal to the number of lines leaving the load. To determine the advantage of a multiple system. see Figure 9-9.

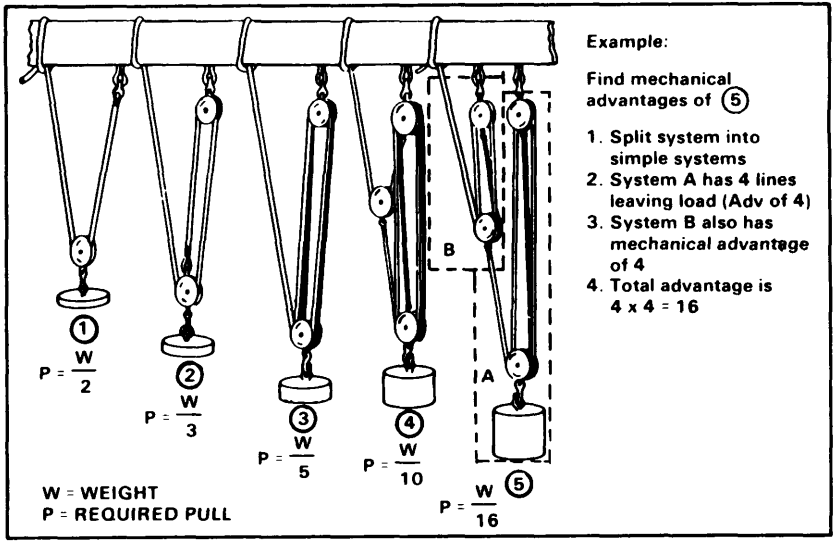
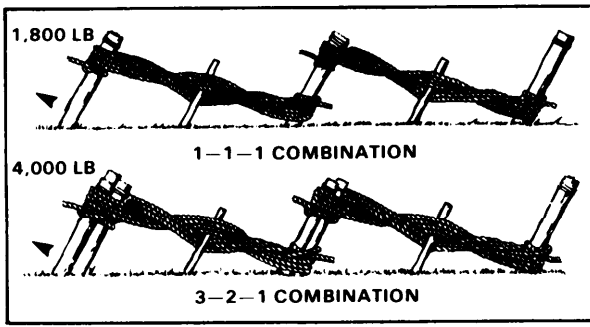



Figure 9-9. Block and tackle systems and mechanical advantages

## ANCHORAGES AND GUY LINES

### Anchorages

Use natural anchorage whenever possible (trees, boulders, and so forth). Figure 9-10 shows the design and characteristics of several picket holdfasts. For deadman design and characteristics, see Chapter 7 (page 7-14).




| TYPE OF HOLDFAST | UNDIS-TURBED EARTH | WET CLAY AND GRAVEL | WET RIVER CLAY AND SAND |
|---|---|---|---|
| Single picket | 700 | 630 | 350 |
| 1—1 Picket holdfast | 1.400 | 1.260 | 700 |
| 1—1—1 Picket holdfast | 1.800 | 1.620 | 900 |
| 2—1 Picket holdfast | 2.000 | 1.800 | 1.000 |
| 3—2—1 Picket holdfast | 4.000 | 3.600 | 2.000 |

**Figure 9-10. Picket holdfast characteristics**

### Guy Lines

Use a minimum of four guy lines for gin poles and boom derrick and two guy lines for shears. To determine what tension will be on a guy line, use the formula.

$$T = \frac{(W_L + \frac{1}{2} W_S)\, D}{Y}$$

Where: $T$ = tension in guy line
$W_L$ = weight of load
$W_S$ = weight of spar
$D$ = drift distance
$Y$ = perpendicular distance

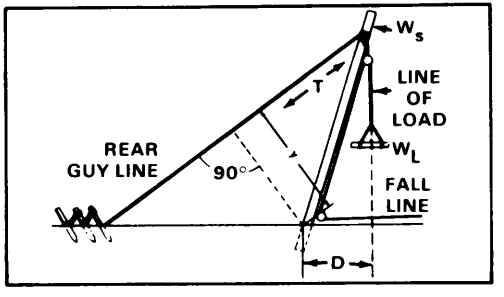



**Figure 9-11. Guy line**

## HIGHLINE

The highline is a trolley line passing through a snatch block at each support (Figure **9-12).**

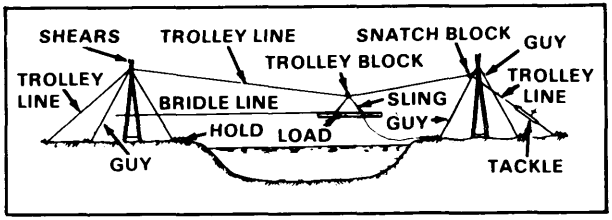



**Figure 9-12. Highline**

### Sag

The sag in the track cable when loaded should be not less than 5 percent of the span.

### Safe Load Highline Formula

$$SL = \frac{BS}{5 \times SF} - \frac{DL}{2}$$

Where: SL = safe load in pounds
BS = breaking strength of line in p
DL = dead load in pounds
SF = safety factor

Problem: Span is 400 feet
Track line is ¾ - inch-diameter manila rope
Haul line is ½ - inch-diameter manila rope
Track cable sag is 5 percent

Solution: BS for ¾ - inch diameter manila rope (Table 9-2. page 9.2)= 5,400 pounds (2.70 tons)
SF for ¾ - inch rope (Table 9-2) = 4.0
DL for ¾ - inch rope (Table 9-2) = 66.8 pounds/400 feet
DL for ½ - inch rope (Table 9-2) = 60 pounds/800 feet

Therefore:

$$SL = \frac{5{,}400}{5 \times 4.0} - \frac{66.8}{2}$$

SL=270-33.4
SL = 236.6 pounds

For the payload, use the formula
PL = SL - (½ W of haul rope + W of traveler + W of carrier)

For this problem, this would mean
PL = 236.6 - (30 plus the weight of the traveler and carrier)

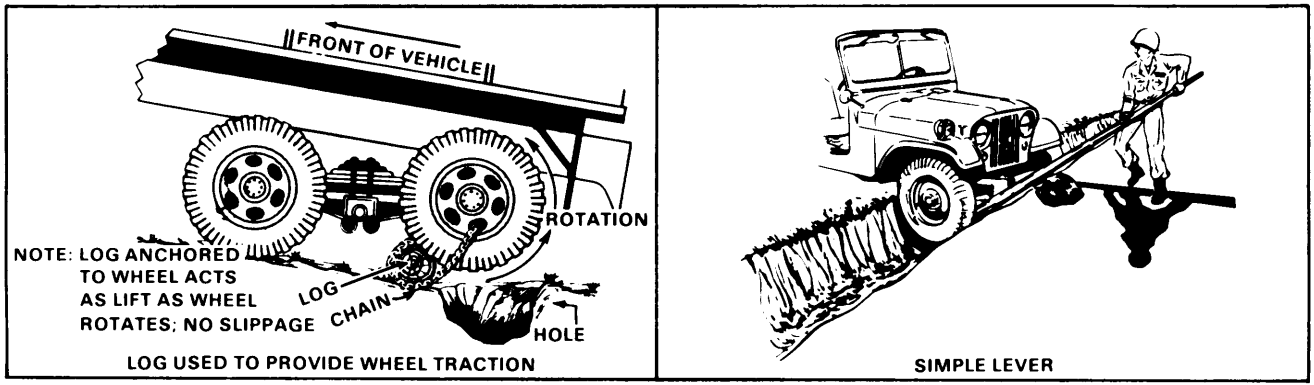



Figure 9-13. Simple lifting techniques

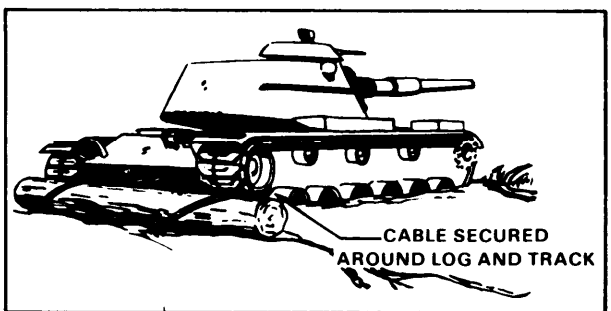



Figure 9-14. Log used to provide truck traction

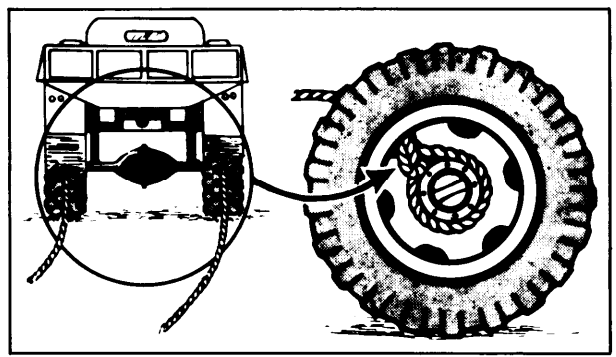


Figure 9-15. Use of dual wheels for a winch

# Chapter 10

# Miscellaneous Field Data

## SPECIFIC WEIGHTS AND GRAVITIES

Table 10-1. Specific weights and gravities

| SUBSTANCE | WEIGHT LB PER CU FT | SPECIFIC GRAVITY | SUBSTANCE | WEIGHT LB PER CU FT | SPECIFIC GRAVITY |
|---|---|---|---|---|---|
| Aluminum, cast, hammered | 165 | 2.55-2.75 | Hay and straw (bales) | 20 | |
| Copper, cast rolled | 556 | 8.8-9.0 | Paper | 58 | 0.70-1.15 |
| Iron, cast, pig | 450 | 7.2 | Stone, quarried, piles | | |
| Lead | 710 | 11.37 | Basalt, granite, gneiss | 96 | |
| Magnesium alloys | 112 | 1.74-1.83 | Greenstone, hornblende | 107 | |
| Steel, rolled | 490 | 7.85 | Limestone, marble, quartz | 90 | |
| Limestone, marble | 165 | 2.5-2.8 | Sandstone | 82 | |
| Sandstone, bluestone | 147 | 2.2-2.5 | Shale | 92 | |
| Riprap, limestone | 80-85 | | Excavations in water | | |
| Riprap, sandstone | 90 | | Clay | 80 | |
| Riprap, shale | 105 | | River mud | 90 | |
| Glass, common | 156 | 2.4-2.6 | Sand or gravel | 60 | |



[redacted]

Table 10-1. Specific weights and gravities (continued)

| SUBSTANCE | WEIGHT LB PER CU FT | SPECIFIC GRAVITY | SUBSTANCE | WEIGHT LB PER CU FT | SPECIFIC GRAVITY |
|---|---|---|---|---|---|
| Excavations in water (continued) | | | Sand gravel, dry, packed | 100-120 | |
| Sand or gravel and clay | 65 | | Sand gravel, wet | 118-120 | |
| Soil or gravel and clay | 70 | | Water, 4° C (max density) | 62.428 | 1.0 |
| Stone riprap | 65 | | Water, ice | 56 | 0.88-0.92 |
| Timber, US, seasoned (moisture | | | Masonry, ashlar | | |
| content by weight 15-50%) | | | Granite, syenite, gneiss | 165 | 2.3-3.0 |
| Soft wood | 25 | 40 | Limestone, marble | 160 | 2.3-2.8 |
| Medium wood | 40 | .63 | Sandstone, bluestone | 140 | 2.1-2.4 |
| Hard wood | 55 | .87 | Masonry, brick | | |
| Asphaltum | 81 | 1.1-1.5 | Pressed brick | 140 | 2.2-2.3 |
| Petroleum, gasoline, and diesel | 42 | 0.66-0.69 | Common brick | 120 | 1.8-2.0 |
| Tar, bituminous | 75 | 1.20 | Soft brick | 100 | 1.5-1.7 |
| Cement, portland, loose | 94 | | Masonry, concrete | | |
| Cement, portland, set | 183 | 2.7-3.2 | Cement, stone, sand | 144 | 2.2-2.4 |
| Clay, damp, plastic | 110 | | Masonry, dry rubble | | |
| Clay, dry | 63 | | Granite, syenite, gneiss | 130 | 1.9-2.3 |
| Earth, dry, loose | 76 | | Limestone, marble | 125 | 1.9-2.1 |
| Earth, dry, packed | 96 | | Sandstone, bluestone | 110 | 1.8-1.9 |
| Earth, moist, loose | 78 | | Masonry, mortar, rubble | | |
| Earth, moist, packed | 96 | | Granite, syenite, gneiss | 155 | 2.2-2.8 |
| Sand gravel, dry, loose | 90-105 | | Limestone, marble | 150 | 2.2-2.6 |
| | | | Sandstone, bluestone | 130 | 2.0-2.2 |

## CONSTRUCTION MATERIAL

### Electrical Wire

Convert load to amperes required by using formula:

$$\text{amperes} = \frac{\text{total wattage required}}{\text{voltages}} = \frac{\text{voltage}}{\text{resistance (ohms)}} = \frac{745.7 \times \text{horsepower}}{\text{voltages}}$$

Enter Table 10-2 or 10-3 using computed amperes and distance to load to obtain wire size. This procedure is used when power is to be furnished to a specific load such as a motor or a group of lights (See FM 20-31 for more details .)

**Table 10-2. Wire sizes for 110-volt single-phase circuits**

| FOR 110V CIRCUIT DISTANCE TO LOAD IN FEET | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LOAD IN AMPS | 50 | 75 | 100 | 125 | 150 | 200 | 250 | 300 | 400 | 500 |
| 15 | 10/12 | 8/10 | 8/10 | 6/8 | 6/8 | 4/6 | 4/6 | 3/4 | 2/4 | 1/3 |
| 20 | 10/12 | 8/10 | 6/8 | 6/8 | 4/6 | 4/6 | 3/4 | 2/4 | 1/3 | 0/2 |
| 25 | 8/10 | 6/8 | 6/8 | 4/6 | 4/6 | 3/4 | 2/4 | 1/3 | 0/2 | 2/0/1 |
| 30 | 6/10 | 6/8 | 4/6 | 4/6 | 3/4 | 2/4 | 1/3 | 0/2 | 2/0/1 | 3/0/0 |
| 40 | 6/8 | 4/6 | 4/6 | 3/4 | 2/4 | 1/3 | 0/2 | 2/0/1 | 3/0/0 | 4/0/2/0 |

10–ALUMINUM WIRE
12–COPPER WIRE

| FOR 110V CIRCUIT DISTANCE TO LOAD IN FEET | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LOAD IN AMPS | 50 | 75 | 100 | 125 | 150 | 200 | 250 | 300 | 400 | 500 |
| 50 | 4/8 | 4/6 | 3/4 | 2/4 | 1/3 | 0/2 | 2/0/1 | 3/0/0 | 4/0/2/0 | 300/3/0 |
| 60 | 4/6 | 2/4 | 2/4 | 1/3 | 0/2 | 2/0/1 | 3/0/0 | 4/0/2/0 | 250/3/0 | 350/4/0 |
| 70 | 4/6 | 2/4 | 1/3 | 0/2 | 2/0/2 | 3/0/0 | 4/0/2/0 | 250/2/0 | 300/4/0 | 400/250 |
| 80 | 4/6 | 2/4 | 1/3 | 0/2 | 2/0/1 | 3/0/0 | 4/0/2/0 | 250/3/0 | 350/4/0 | 500/250 |
| 90 | 2/4 | 1/3 | 0/2 | 2/0/1 | 3/0/1 | 4/0/2/0 | 250/3/0 | 300/3/0 | 400/250 | 500/300 |
| 100 | 2/4 | 1/3 | 0/2 | 2/0/1 | 3/0/0 | 4/0/2/0 | 300/3/0 | 350/4/0 | 500/250 | 600/350 |

Table 10-3. Wire sizes for 220-volt three-phase circuits

| LOAD IN AMPS | FOR 220V CIRCUIT DISTANCE TO LOAD IN FEET | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1.000 |
| 15 | 12/12 | 8/10 | 6/8 | 4/6 | 4/6 | 3/4 | 2/4 | 2/4 | 1/3 | 1/3 |
| 20 | 10/12 | 6/8 | 4/6 | 4/6 | 3/4 | 2/4 | 1/3 | 1/3 | 0/2 | 0/2 |
| 25 | 8/10 | 6/8 | 4/6 | 3/4 | 2/4 | 1/3 | 0/2 | 0/2 | 2/0/1 | 2/0/1 |
| 30 | 6/10 | 4/6 | 3/4 | 2/4 | 1/3 | 0/2 | 2/0/2 | 2/0/1 | 3/0/0 | 3/0/0 |
| 40 | 4/8 | 4/6 | 2/4 | 1/3 | 0/2 | 2/0/1 | 3/0/0 | 3/0/0 | 4/0/2/0 | 4/0/2/0 |

10—ALUMINUM WIRE
12—COPPER WIRE

| LOAD IN AMPS | FOR 220V CIRCUIT DISTANCE TO LOAD IN FEET | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1.000 |
| 50 | 4/8 | 3/4 | 1/3 | 0/2 | 2/0/1 | 3/0/0 | 4/0/2/0 | 4/0/2/0 | 250/3/0 | 300/3/0 |
| 60 | 4/6 | 2/4 | 0/2 | 2/0/1 | 3/0/0 | 4/0/2/0 | 250/2/0 | 250/3/0 | 300/4/0 | 350/4/0 |
| 70 | 4/6 | 1/3 | 2/0/2 | 3/0/0 | 4/0/2/0 | 250/2/0 | 300/3/0 | 300/4/0 | 350/4/0 | 400/250 |
| 80 | 4/6 | 1/3 | 2/0/1 | 3/0/0 | 4/0/2/0 | 250/3/0 | 300/4/0 | 350/4/0 | 400/250 | 500/250 |
| 90 | 2/4 | 0/2 | 3/0/0 | 4/0/2/0 | 250/3/0 | 300/4/0 | 350/4/0 | 400/250 | 500/300 | 500/300 |
| 100 | 2/4 | 0/2 | 3/0/0 | 4/0/2/0 | 300/3/0 | 350/4/0 | 400/250 | 500/250 | 500/300 | 600/350 |

## Lumber Data

Table 10-4. Properties of southern pine

| NOMINAL SIZE | ACTUAL SIZE DRESSED | AREA OF SECTION IN SQ IN | WEIGHT PER FOOT (LB) |
|---|---|---|---|
| 2 x 4 | 1 5/8 x 3 5/8 | 5.89 | 1.63 |
| 4 x 4 | 3 5/8 x 3 5/8 | 13.14 | 3.64 |
| 2 x 6 | 1 5/8 x 5 5/8 | 9.14 | 2.53 |
| 6 x 6 | 5 5/8 x 5 5/8 | 31.64 | 8.76 |
| 2 x 8 | 1 5/8 x 7 1/2 | 12.19 | 3.38 |
| 4 x 8 | 3 5/8 x 7 1/2 | 27.19 | 7.55 |
| 6 x 8 | 5 5/8 x 7 1/2 | 42.19 | 11.72 |
| 8 x 8 | 7 1/2 x 7 1/2 | 56.25 | 15.58 |
| 2 x 10 | 1 5/8 x 9 1/2 | 15.44 | 4.28 |
| 6 x 10 | 5 5/8 x 9 1/2 | 53.44 | 14.84 |
| 10 x 10 | 9 1/2 x 9 1/2 | 90.25 | 25.00 |
| 2 x 12 | 1 5/8 x 11 1/2 | 18.69 | 5.18 |
| 3 x 12 | 2 5/8 x 11 1/2 | 30.19 | 8.39 |
| 6 x 12 | 5 5/8 x 11 1/2 | 64.69 | 17.96 |
| 8 x 12 | 7 1/2 x 11 1/2 | 86.25 | 23.89 |
| 10 x 12 | 9 1/2 x 11 1/2 | 109.25 | 30.26 |
| 2 x 14 | 1 5/8 x 13 1/2 | 21.94 | 6.09 |
| 3 x 14 | 2 5/8 x 13 1/2 | 35.44 | 9.84 |
| 6 x 14 | 5 5/8 x 13 1/2 | 75.94 | 21.09 |
| 10 x 14 | 9 1/2 x 13 1/2 | 128.25 | 35.53 |
| 14 x 14 | 13 1/2 x 13 1/2 | 182.25 | 50.48 |
| 2 x 16 | 1 5/8 x 15 1/2 | 25.19 | 7.00 |
| 3 x 16 | 2 5/8 x 15 1/2 | 40.69 | 11.30 |
| 8 x 16 | 7 1/2 x 15 1/2 | 116.25 | 32.20 |
| 12 x 16 | 11 1/2 x 15 1/2 | 178.25 | 49.37 |
| 14 x 16 | 13 1/2 x 15 1/2 | 209.25 | 57.96 |
| 16 x 16 | 15 1/2 x 15 1/2 | 240.25 | 66.55 |
| 4 x 18 | 3 5/8 x 17 1/2 | 63.44 | 17.62 |
| 8 x 18 | 7 1/2 x 17 1/2 | 131.25 | 36.36 |
| 12 x 18 | 11 1/2 x 17 1/2 | 201.25 | 55.75 |

**NOTE:** In some species 5 ½" is the dressed size for nominal 6" x 6" and larger.

## Fasteners

Table 10-5. Wood screw diameters

| SIZE | DIAMETER-D INCHES | $D^2$ INCHES$^2$ |
|---|---|---|
| 1/2 inch—No. 4 | .1105 | .0122 |
| 3/4 inch—No. 8 | .1631 | .0266 |
| 1 inch—No. 10 | .1894 | .0359 |
| 1 1/2 inch—No. 12 | .2158 | .0466 |
| 2 inch—No. 14 | .2421 | .0586 |
| 2 1/2 inch—No. 16 | .2684 | .0720 |
| 3 inch—No. 18 | .2947 | .0868 |

Table 10-6. Nail and spike sizes

| SIZE | LENGTH, IN | COMMON | | | | FINISHING | | FLOORING | |
|---|---|---|---|---|---|---|---|---|---|
| | | GAGE | NO./LB | DIAMETER (D) INCHES | D3/2 | GAGE | NO./LB | GAGE | NO./LB |
| 3D | 1 1/4 | 14 | 568 | .0800 | .0226 | 15 1/2 | 807 | | |
| 4D | 1 1/2 | 12 1/2 | 316 | .0985 | .0309 | 15 | 584 | | |
| 6D | 2 | 11 1/2 | 181 | .1130 | .0380 | 13 | 309 | 11 | 157 |
| 8D | 2 1/2 | 10 1/4 | 106 | .1314 | .0476 | 12 1/2 | 189 | 10 | 99 |
| 10D | 3 | 9 | 69 | .1483 | .0570 | 11 1/2 | 121 | 9 | 69 |
| 12D | 3 1/4 | 9 | 63 | .1552 | .0611 | 11 1/2 | 113 | 8 | 54 |
| 16D | 3 1/2 | 8 | 49 | .1620 | .0652 | 11 | 90 | 7 | 43 |
| 20D | 4 | 6 | 31 | .1920 | .0841 | 10 | 61 | 6 | 31 |
| 30D | 4 1/2 | 5 | 24 | .2070 | .0942 | | | | |
| 40D | 5 | 4 | 18 | .2253 | .1066 | | | | |
| 60D | 6 | 2 | 11 | .2625 | .1347 | | | | |
| SPIKES | | | | | | | | | |
| 7" | 7" | 5/16" | | 5/16" | .1750 | | | | |
| 8" | 8" | 3/8" | | 3/8" | .2295 | | | | |
| 9" | 9" | 3/8" | | 3/8" | .2295 | | | | |
| 10" | 10" | 3/8" | | 3/8" | .2295 | | | | |
| 12" | 12" | 3/8" | | 3/8" | .2295 | | | | |

NOTE: To avoid splitting, nail diameters should not exceed one-seventh of the thickness of lumber to be nailed.

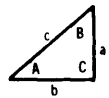
Formula to find approximate number of nails required.
Number of pounds (12D to 60D, framing) =D/6 x BF/100
Number of pounds (2D to 12D, sheathing) = D/4 x BF/100
Where D = size of desired nail in pennies
BF = total board feet to be nailed

## SOIL CONVERSION

Table 10-7. Soil conversion factors

| SOIL TYPE | INITIAL SOIL CONDITION | CONVERTED TO: IN PLACE | LOOSE | COMPACTED |
|---|---|---|---|---|
| Sand | In Place | | 1.11 | .95 |
| | Loose | .90 | | .86 |
| | Compacted | 1.05 | 1.17 | |
| Loam | In Place | | 1.25 | .90 |
| | Loose | .80 | | .72 |
| | Compacted | 1.11 | 1.39 | |
| Clay | In Place | | 1.43 | .90 |
| | Loose | .70 | | .63 |
| | Compacted | 1.11 | 1.59 | |
| Rock (blasted) | In Place | | 1.50 | 1.30 |
| | Loose | .67 | | .87 |
| | Compacted | .77 | 1.15 | |

Table 10-8. Trigonometric functions



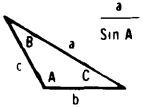

$a^2 = c^2 - b^2$ Sin A = a/c

$b^2 = c^2 - a^2$ Cos A = b/c

$c^2 = a^2 + b^2$ Tan A = a/b

| RIGHT TRIANGLE | | | | | | | |
|---|---|---|---|---|---|---|---|
| | TO FIND | | | | | | |
| GIVEN | A | B | C | a | b | c | AREA |
| a,b | $\tan A = \frac{a}{b}$ | $\tan B = \frac{b}{a}$ | 90° | | | $\sqrt{a^2 + b^2}$ | $\frac{ab}{2}$ |
| a,c | $\sin A = \frac{a}{c}$ | $\cos B = \frac{a}{c}$ | 90° | | $\sqrt{c^2 - a^2}$ | | $\frac{a}{2}\sqrt{c^2 - a^2}$ |
| A,a | | 90° - A | 90° | | a cot A | $\frac{a}{\sin A}$ | $\frac{a^2 \cot A}{2}$ |
| A,b | | 90° - A | 90° | b tan A | | $\frac{b}{\cos A}$ | $\frac{b^2 \tan A}{2}$ |
| A,c | | 90° - A | 90° | c sin A | c cos A | | $\frac{c^2 \sin 2A}{4}$ |

Table 10-8. Trigonometric functions (continued)




$$\frac{a}{\text{Sin } A} \qquad \frac{b}{\text{Sin } B} \qquad \frac{c}{\text{Sin } C}$$

$a^2 \quad b^2 + c^2 - 2bc \text{ Cos } A$

$b^2 \quad a^2 + c^2 - 2ac \text{ Cos } B$

$c^2 \quad a^2 + b^2 - 2ab \text{ Cos } C$

$S \quad \frac{a + b + c}{2}$

**OBLIQUE TRIANGLE**

| GIVEN | TO FIND | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | C | a | b | c | AREA |
| a.b.c | $\cos \frac{A}{2} \sqrt{\frac{s(s-a)}{bc}}$ | $\cos \frac{B}{2} \sqrt{\frac{s(s-b)}{ac}}$ | $\cos \frac{C}{2} \sqrt{\frac{s(s-c)}{ab}}$ | | | | $\sqrt{s(s-a)(s-b)(s-c)}$ |
| a.A.B | | | $180^\circ - (A + B)$ | | $\frac{a \sin B}{\sin A}$ | $\frac{a \sin C}{\sin A}$ | $\frac{a^2 \sin B \sin C}{2 \sin A}$ |
| a.b.A | | $\sin B = \frac{b \sin A}{a}$ | | | | $\frac{b \sin C}{\sin B}$ | |
| a.b.c | | $\tan A = \frac{a \sin C}{b - a \cos C}$ | | | | $\sqrt{a^2 + b^2 - 2ab \cos C}$ | $\frac{ab \sin C}{2}$ |

Table 10-8. Trigonometric functions (continued)

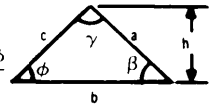
| DEGREE OF ANGLE | SINE | COSECANT | TANGENT | COTANGENT | SECANT | COSINE | DEGREE OF ANGLE |
|---|---|---|---|---|---|---|---|
| 0 | .000 | | .000 | | 1.000 | 1.000 | 90 |
| 1 | .017 | 57.30 | .017 | 57.29 | 1.000 | 1.000 | 89 |
| 2 | .035 | 28.65 | .035 | 28.64 | 1.001 | .999 | 88 |
| 3 | .052 | 19.11 | .052 | 19.08 | 1.001 | .999 | 87 |
| 4 | .070 | 14.34 | .070 | 14.30 | 1.002 | .998 | 86 |
| 5 | .087 | 11.47 | .087 | 11.43 | 1.004 | .996 | 85 |
| 6 | .105 | 9.567 | .105 | 9.514 | 1.006 | .995 | 84 |
| 7 | .122 | 8.206 | .123 | 8.144 | 1.008 | .993 | 83 |
| 8 | .139 | 7.185 | .141 | 7.115 | 1.010 | .990 | 82 |
| 9 | .156 | 6.392 | .158 | 6.314 | 1.012 | .988 | 81 |
| 10 | .174 | 5.759 | .176 | 5.671 | 1.015 | .985 | 80 |
| 11 | .191 | 5.241 | .194 | 5.145 | 1.019 | .982 | 79 |
| 12 | .208 | 4.810 | .213 | 4.705 | 1.022 | .978 | 78 |
| 13 | .225 | 4.445 | .231 | 4.331 | 1.026 | .974 | 77 |
| 14 | .242 | 4.134 | .249 | 4.011 | 1.031 | .970 | 76 |
| 15 | .259 | 3.864 | .268 | 3.732 | 1.035 | .966 | 75 |
| 16 | .276 | 3.628 | .287 | 3.487 | 1.040 | .961 | 74 |
| 17 | .292 | 3.420 | .306 | 3.271 | 1.046 | .956 | 73 |
| 18 | .309 | 3.236 | .325 | 3.078 | 1.051 | .951 | 72 |
| 19 | .326 | 3.072 | .344 | 2.904 | 1.058 | .946 | 71 |
| 20 | .342 | 2.924 | .364 | 2.747 | 1.064 | .940 | 70 |
| 21 | .358 | 2.790 | .384 | 2.605 | 1.071 | .934 | 69 |
| 22 | .375 | 2.669 | .404 | 2.475 | 1.079 | .927 | 68 |
| 23 | .391 | 2.559 | .424 | 2.356 | 1.086 | .921 | 67 |
| 24 | .407 | 2.459 | .445 | 2.246 | 1.095 | .914 | 66 |
| 25 | .423 | 2.366 | .466 | 2.145 | 1.103 | .906 | 65 |
| 26 | .438 | 2.281 | .488 | 2.050 | 1.113 | .899 | 64 |
| 27 | .454 | 2.203 | .510 | 1.963 | 1.122 | .891 | 63 |
| 28 | .469 | 2.130 | .532 | 1.881 | 1.133 | .883 | x62 |
| 29 | .485 | 2.063 | .554 | 1.804 | 1.143 | .875 | 61 |
| 30 | .500 | 2.000 | .577 | 1.732 | 1.155 | .866 | 60 |
| 31 | .515 | 1.942 | .601 | 1.664 | 1.167 | .857 | 59 |
| 32 | .530 | 1.887 | .625 | 1.600 | 1.179 | .848 | 58 |
| 33 | .545 | 1.836 | .649 | 1.540 | 1.192 | .839 | 57 |
| 34 | .559 | 1.788 | .675 | 1.483 | 1.206 | .829 | 56 |
| 35 | .574 | 1.743 | .700 | 1.428 | 1.221 | .819 | 55 |
| 36 | .588 | 1.701 | .727 | 1.376 | 1.236 | .809 | 54 |
| 37 | .602 | 1.662 | .754 | 1.327 | 1.252 | .799 | 53 |
| 38 | .616 | 1.624 | .781 | 1.280 | 1.269 | .788 | 52 |
| 39 | .629 | 1.589 | .810 | 1.235 | 1.287 | .777 | 51 |
| 40 | .643 | 1.556 | .839 | 1.192 | 1.305 | .766 | 50 |
| 41 | .656 | 1.542 | .869 | 1.150 | 1.325 | .755 | 49 |
| 42 | .669 | 1.494 | .900 | 1.111 | 1.346 | .743 | 48 |
| 43 | .682 | 1.466 | .933 | 1.072 | 1.367 | .731 | 47 |
| 44 | .695 | 1.440 | .966 | 1.036 | 1.390 | .719 | 46 |
| 45 | .707 | 1.414 | 1.000 | 1.100 | 1.414 | .707 | 45 |
| DEGREE OF ANGLE | COSINE | SECANT | COTANGENT | TANGENT | COSECANT | SINE | DEGREE OF ANGLE |

Table 10-9. Geometric figures and formulas

(1) Any triangle:

$A = 1/2bh$

or: $\sin \gamma = \frac{c \sin \phi}{a}$

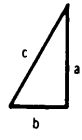



(2) Right triangle

$a = \sqrt{c^2 - b^2}$

$b = \sqrt{c^2 - a^2}$

$c = \sqrt{a^2 + b^2}$

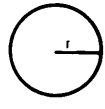



(3) Circle:

$A = \pi r^2$

$A = 0.7854\ D^2$

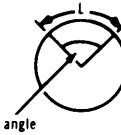
$C = \pi D$




(4) Segment of circle:

$A = \frac{\pi r^2 a}{360} - \frac{r^2 \sin a}{2}$

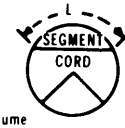
$L = \frac{2 \pi r a}{360}$




a = angle in degrees

(5) Sector of circle:

$A = \frac{rL}{2} = \frac{\pi r^2 a}{360}$



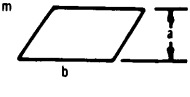

A = area
h = height
b = length of base
c = hypotenuse
C = circumference
V = volume
r = radius
D = diameter
$\pi$ = 3.1416
L = length of arc
K = length of cord

(6) Regular polygons. The area of any regular polygon (all sides equal, all angles equal) is equal to the product of the square of the lengths of one side and the factors. Example problem: Area of a regular octagon having 6-inch sides is 6 x 6 x 4.828, or 173.81 square inches. See factors in table.

| POLYGON FACTORS | | | |
|---|---|---|---|
| NO. OF SIDES | FACTOR | NO. OF SIDES | FACTOR |
| 3 | 0.433 | 8 | 4.828 |
| 4 | 1.000 | 9 | 6.182 |
| 5 | 1.720 | 10 | 7.694 |
| 6 | 2.598 | 11 | 9.366 |
| 7 | 3.634 | 12 | 11.196 |

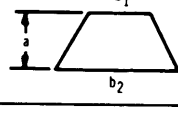
(7) Rectangle and parallelogram

$A = ab$



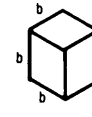

(8) Trapezoid:

$A = \frac{1}{2}a(b_1 + b_2)$



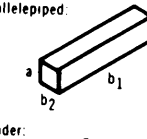

(9) Cube:

$V = b^3$



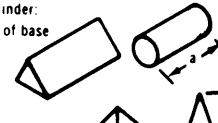

(10) Rectangular parallelepiped:

$V = ab_1 b_2$




(11) Prism or cylinder:

V = a x area of base




(12) Pyramid or cone:

V = (1/3)a x area of base

(13) Sphere:

$V = (4/3)\pi r^3 = \frac{\pi D^3}{6}$

$A = 4 \pi r^2$

## CONVERSION FACTORS
### Unit

Table 10-10. Conversion factors

| MULTIPLY | BY | TO OBTAIN |
|---|---|---|
| acres | 43.560 | square feet |
| acres | 4.047 | square meters |
| acres | $1.562 \times 10^{-3}$ | square miles |
| acres | 5645.38 | square varas |
| acres | 4.840 | square yards |
| acre—feet | 43.560 | cubic—feet |
| acres | 100 | square meters |
| atmospheres | 76.0 | cms of mercury |
| atmospheres | 29.92 | inches of mercury |
| atmospheres | 33.90 | feet of water |
| atmospheres | 14.70 | pounds per sq inch |
| board—feet | 144 sq in x 1 in | cubic inches |
| BTU | 0.2520 | kilogram—calories |
| BTU | 777.5 | foot—pounds |
| BTU | $2.928 \times 10^{-4}$ | kilowatt—hours |
| BTU per min | 0.02356 | horsepower |
| BTU per min | 0.01757 | kilowatts |
| BTU per min | 17.57 | watts |
| bushels | 1.244 | cubic feet |
| centares | 1 | square meters |
| centigrams | 0.01 | grams |
| centiliters | 0.01 | liters |
| centimeters | 0.3937 | inches |
| centimeters | 0.01 | meters |
| centimeters | 393.7 | mils |
| centimeters | 10 | millimeters |
| centimeters—grams | $10^{-5}$ | meter—kilograms |
| centimeters—grams | $7.233 \times 10^{-5}$ | pound—feet |
| cms of mercury | 0.01316 | atmospheres |
| cms of mercury | 0.4461 | feet of water |
| cms of mercury | 136.0 | kgs of sq meter |
| cms of mercury | 27.85 | pounds per sq foot |
| cms of mercury | 0.1934 | pounds per sq inch |
| cms per second | 0.6 | meters per min |
| circular mils | 0.7854 | square mils |
| cord—feet | 4 ft x 4 ft x 1 ft | cubic feet |
| cords | 8 ft x 4 ft x 4 ft | cubic feet |
| cubic cms | $6.102 \times 10^{-2}$ | cubic inches |
| cubic cms | $10^{-6}$ | cubic meters |
| cubic cms | $2.642 \times 10^{-4}$ | gallons |
| cubic cms | $10^{-3}$ | liters |
| cubic feet | $2.832 \times 10^{4}$ | cubic cms |
| cubic feet | 1.728 | cubic inches |
| cubic feet | 0.02832 | cubic meters |
| cubic feet | 0.03704 | cubic yards |
| cubic feet | 7.481 | gallons |
| cubic feet | 28.32 | liters |
| cubic feet per min | 472.0 | cubic cms per sec |
| cubic feet per min | 0.1247 | gallons per sec |
| cubic feet per min | 0.4720 | liters per sec |
| cubic feet per min | 62.4 | lb of water per min |
| cubic inches | 16.39 | cubic cms |
| cubic inches | $5.787 \times 10^{-4}$ | cubic feet |
| cubic inches | 0.01732 | quarts (liq) |
| cubic meters | $10^{6}$ | cubic cms |
| cubic meters | 35.31 | cubic feet |
| cubic meters | 1.308 | cubic yards |
| cubic meters | 264.2 | gallons |
| cubic yards | 27 | cubic feet |
| cubic yards | 0.7646 | cubic meters |
| cubic yards | 202.0 | gallons |
| cubic yards per min | 0.45 | cubic feet per sec |
| cubic yards per min | 3.367 | gallons per sec |

Table 10-10. Conversion factors (continued)

| MULTIPLY | BY | TO OBTAIN |
|---|---|---|
| decigrams | 0.1 | grams |
| deciliters | 0.1 | liters |
| decimeters | 0.1 | meters |
| degrees (angle) | 60 | minutes |
| degrees (angle) | 0.01745 | radians |
| degrees (angle) | 3600 | seconds |
| dekagrams | 10 | grams |
| dekaliters | 10 | liters |
| dekameters | 10 | meters |
| drams | 1.772 | grams |
| drams | 0.0625 | ounces |
| ergs | $9.486 \times 10^{-11}$ | BTU |
| fathoms | 6 | feet |
| feet | 0.3048 | meters |
| feet | 36 | varas |
| feet | 1/3 | yards |
| feet of water | 0.4335 | pounds per sq inch |
| feet per min | 0.5080 | centimeters per sec |
| feet per min | 0.01667 | feet per sec |
| feet per min | 0.01136 | miles per hour |
| feet per sec | 1.097 | kilometers per hour |
| feet per sec | 0.5921 | knots per hour |
| feet per sec | 18.29 | meters per min |
| feet per sec | 0.6818 | miles per hour |
| feet per 100 feet | 1 | percent grade |
| foot—pounds | $1.286 \times 10^{-3}$ | BTU |
| foot—pounds | $1.356 \times 10^{7}$ | ergs |
| foot—pounds | $5.050 \times 10^{-7}$ | horsepower—hours |
| foot—pounds | $3.241 \times 10^{-4}$ | kilogram—calories |
| foot—pounds | $3.766 \times 10^{-7}$ | kilowatt—hours |
| foot—pounds per min | $1.286 \times 10^{-3}$ | BTU per min |
| foot—pounds per min | $3.030 \times 10^{-5}$ | horsepower |

| MULTIPLY | BY | TO OBTAIN |
|---|---|---|
| foot—pounds per min | $3.241 \times 10^{-4}$ | kg—calories per min |
| foot—pounds per min | $2.260 \times 10^{-5}$ | kilowatts |
| furlongs | 40 | rods |
| gallons | 3785 | cubic cms |
| gallons | 0.1337 | cubic feet |
| gallons | 231 | cubic inches |
| gallons | $3.785 \times 10^{-3}$ | cubic meters |
| gallons | $4.951 \times 10^{-3}$ | cubic yards |
| gallons per min | $2.228 \times 10^{-3}$ | cubic feet per sec |
| gills | 0.1183 | liters |
| grains (troy) | 1 | grains (av) |
| grains (troy) | 0.06480 | grams |
| grains (troy) | 0.04167 | pennyweights (troy) |
| grams | 980.7 | dynes |
| grams | 15.43 | grains (troy) |
| grams | $10^{-3}$ | kilograms |
| grams | $10^{3}$ | milligrams |
| grams | 0.03527 | ounces |
| grams | 0.03215 | ounces (troy) |
| grams | $2.205 \times 10^{-3}$ | pounds |
| grams—calories | $3.968 \times 10^{-3}$ | BTU |
| gram—cms | $2.344 \times 10^{-8}$ | kilogram—calories |
| gram—cms | $10^{-5}$ | kilogram—meters |
| grams per cm | $5.600 \times 10^{-3}$ | pounds per inch |
| grams per cu cm | 62.43 | pounds per cubic foot |
| hectares | 2.471 | acres |
| hectares | $1.076 \times 10^{5}$ | square feet |
| hectograms | 100 | grams |
| hectoliters | 100 | liters |
| hectometers | 100 | meters |
| hectowatts | 100 | watts |

Table 10-10. Conversion factors (continued)

| MULTIPLY | BY | TO OBTAIN |
|---|---|---|
| horsepower | 42.44 | BTU per min |
| horsepower | 33,000 | foot—pounds per min |
| horsepower | 550 | foot—pounds per sec |
| horsepower | 1.014 | horsepower (metric) |
| horsepower | 10.70 | kg—calories per min |
| horsepower | 0.7457 | kilowatts |
| horsepower | 745.7 | watts |
| inches | 2.540 | centimeters |
| inches | $10^3$ | mils |
| inches | .03 | varas |
| inches | 0.03342 | atmospheres |
| inches of mercury | 1.133 | feet of water |
| inches of mercury | 70.73 | pounds per sq foot |
| inches of water | 0.002458 | atmospheres |
| inches of water | 0.07355 | inches of mercury |
| inches of water | 0.5781 | ounces per sq inch |
| inches of water | 5.204 | pounds per sq foot |
| inches of water | 0.03613 | pounds per sq inch |
| joules | $9.486 \times 10^{-4}$ | BTU |
| joules | $10^7$ | ergs |
| joules | 0.7376 | foot—pounds |
| joules | $2.390 \times 10^{-4}$ | kilogram—calories |
| joules | 0.1020 | kilogram—meters |
| joules | $2.778 \times 10^{-4}$ | watt—hours |
| kilograms | 980,665 | dynes |
| kilograms | $10^3$ | grams |
| kilograms | 2.2046 | pounds |
| kilograms | $1.102 \times 10^3$ | tons (short) |
| kilogram—calories | 3.968 | BTU |
| kilogram—calories | 3088 | foot—pounds |
| kilogram—calories | $1.588 \times 10^{-3}$ | horsepower—hours |

| MULTIPLY | BY | TO OBTAIN |
|---|---|---|
| kg—calories | $1.162 \times 10^{-3}$ | kilowatt—hours |
| kg—calories per min | 0.06972 | kilowatts |
| kg—meters | $9.302 \times 10^{-3}$ | BTU |
| kg—meters | $9.807 \times 10^7$ | ergs |
| kgs per cubic meter | $10^{-3}$ | grams per cubic cm |
| kgs per cubic meter | 0.06243 | pounds per cubic foot |
| kgs per sq meter | $9.678 \times 10^{-5}$ | atmospheres |
| kgs per sq meter | $3.281 \times 10^{-3}$ | feet of water |
| kgs per sq meter | $2.896 \times 10^{-3}$ | inches of mercury |
| kgs per sq meter | 0.2048 | pounds per sq foot |
| kgs per sq meter | $1.422 \times 10^{-3}$ | pounds per sq inch |
| kiloliters | $10^3$ | liters |
| kilometers | $10^5$ | centimeters |
| kilometers | 3281 | feet |
| kilometers | $10^3$ | meters |
| kilometers | 0.6214 | miles |
| kilometers per hour | 0.5396 | knots per hour |
| kilowatts | 56.92 | BTU per min |
| kilowatts | $4.425 \times 10^4$ | foot—pounds per min |
| kilowatts | 1.341 | horsepower |
| kilowatts—hour | 3415 | BTU |
| kilowatts—hours | $2.655 \times 10^6$ | foot—pounds |
| knots | 1.853 | kilometers per hour |
| knots | 1.152 | miles per hour |
| links (engineer's) | 12 | inches |
| links (surveyor's) | 7.92 | inches |
| liters | $10^3$ | cubic cms |
| liters | 0.2642 | gallons |
| liters | 1.057 | quarts (liq) |
| liters per min | $5.885 \times 10^{-4}$ | cubic feet per sec |
| liters per min | $4.403 \times 10^{-3}$ | gallons per sec |

Table 10-10. Conversion factors (continued)

| MULTIPLY | BY | TO OBTAIN |
|---|---|---|
| meters | 100 | centimeters |
| meters | 3.2808 | feet |
| meters | 39.37 | inches |
| meters | $10^{-3}$ | kilometers |
| meters | $10^{3}$ | millimeters |
| meters | 1.0936 | yards |
| microns | $10^{-6}$ | meters |
| miles | 5280 | feet |
| miles | 1.6093 | kilometers |
| miles | 1760 | yards |
| miles per hour | 1.467 | feet per sec |
| miles per hour | 1.6093 | kilometers per hour |
| miles per hour | 0.8684 | knots per hour |
| milliers | $10^{3}$ | kilograms |
| milligrams | $10^{-3}$ | grams |
| milliliters | $10^{-3}$ | liters |
| millimeters | 0.1 | centimeters |
| millimeters | 0.03937 | inches |
| millimeters | 39.37 | mils |
| mils | 0.002540 | centimeters |
| mils | $10^{-3}$ | inches |
| minutes (angle) | $2.909 \times 10^{-4}$ | radians |
| minutes (angle) | 60 | seconds (angle) |
| myriagrams | 10 | kilograms |
| myriameters | 10 | kilometers |
| myriawatts | 10 | kilowatts |
| nautical miles | 1.152 | miles |
| nautical miles | 2027 | yards |
| ounces | 8 | drams |
| ounces | 437.5 | grains |
| ounces | 28.35 | grams |
| ounces | 0.0625 | pounds |
| ounces (fluid) | 1.805 | cubic inches |
| ounces (troy) | 480 | grains (troy) |
| ounces (troy) | 31.10 | grams |
| ounces (troy) | 20 | pennyweights (troy) |
| ounces (troy) | 0.08333 | pounds (troy) |
| perches (masonry) | 24.75 | cubic feet |
| pints (dry) | 33.60 | cubic inches |
| pints (liq) | 28.87 | cubic inches |
| pounds | 444.823 | dynes |
| pounds | 453.6 | grams |
| pounds | 16 | ounces |
| pounds | 32.17 | poundals |
| pound—feet | $1.356 \times 10^{7}$ | centimeter—dynes |
| pound—feet | 13.825 | centimeter—grams |
| pound—feet | 0.1383 | meter—kilograms |
| pounds of water | 0.01602 | cubic feet |
| pounds of water | 27.68 | cubic inches |
| pounds of water | 0.1198 | gallons |
| pounds per cubic foot | 16.02 | kgs per cubic meter |
| pounds per cubic inch | 27.68 | grams per cubic cm |
| pounds per foot | 1.488 | kgs per meter |
| pounds per sq foot | 0.01602 | feet of water |
| pounds per sq foot | 4.882 | kgs per sq meter |
| pounds per sq inch | 0.06804 | atmospheres |
| pounds per sq inch | 2.307 | feet of water |
| pounds per sq inch | 2.036 | inches of mercury |
| pounds per sq inch | 703.1 | kgs per square meter |
| pounds per sq inch | 144 | pounds per sq foot |
| quadrants (angle) | 90 | degrees |
| quadrants (angle) | 5400 | minutes |
| quadrants (angle) | 1.571 | radians |
| quarts (dry) | 67.20 | cubic inches |
| quarts (liq) | 57.75 | cubic inches |

Table 10-10. Conversion factors (continued)

| MULTIPLY | BY | TO OBTAIN |
|---|---|---|
| radians | 57.30 | degrees |
| radians | 3438 | minutes |
| radians | 0637 | quadrants |
| reams | 500 | sheets |
| revolutions | 360 | degrees |
| revolutions | 4 | quadrants |
| revolutions | 6.283 | radians |
| revs per min | 6 | degrees per sec |
| revs per min | 0.1047 | radians per sec |
| revs per min | 0.01667 | revs per sec |
| revs per min per min | $1.745 \times 10^{-3}$ | rads per sec per sec |
| revs per min per min | 0.01667 | revs per min per sec |
| revs per min per min | $2.778 \times 10^{-4}$ | revs per sec per sec |
| revs per sec | 360 | degrees per sec |
| revs per sec | 6.283 | radians per sec |
| rods | 16.5 | feet |
| seconds (angle) | $4.848 \times 10^{-6}$ | radians |
| square centimeters | 0.1550 | square inches |
| square centimeters | 100 | square millimeters |
| square feet | $2.296 \times 10^{-5}$ | acres |
| square feet | 0.0290 | square meters |
| square feet | $3.587 \times 10^{-8}$ | square miles |
| square feet | 1296 | square varas |
| square feet | 1/9 | square yards |
| square inches | 6.452 | square cms |
| square inches | $6.944 \times 10^{-3}$ | square feet |
| square kilometers | 247.1 | acres |
| square kilometers | $10.76 \times 10^{6}$ | square feet |
| square kilometers | $10^{6}$ | square meters |
| square kilometers | 0.3861 | square miles |
| square kilometers | $1.196 \times 10^{6}$ | square yards |
| square meters | $2.471 \times 10^{-4}$ | acres |
| square meters | 10.764 | square feet |

| MULTIPLY | BY | TO OBTAIN |
|---|---|---|
| square meters | $3.861 \times 10^{-7}$ | square miles |
| square meters | 1.196 | square yards |
| square miles | 640 | acres |
| square miles | $27.88 \times 10^{6}$ | square feet |
| square miles | 2.590 | square kilometers |
| square miles | 3.613.040 45 | square varas |
| square miles | $3.098 \times 10^{6}$ | square yards |
| square yards | $2.066 \times 10^{-4}$ | acres |
| square yards | 9 | square feet |
| square yards | 0.8361 | square meters |
| square yards | $3.228 \times 10^{-7}$ | square miles |
| square yards | 1.1664 | square varas |
| steradians | 0.1592 | hemispheres |
| steres | $10^{3}$ | liters |
| temp (degs C) + 273 | 1 | abs temp (degs C) |
| temp (degs C) + 17.8 | 1.8 | temp (degs F) |
| temp (degs F) + 460 | 1 | abs temp (degs F) |
| temp (degs F) - 32 | 5/9 | temp (degs C) |
| tons (long) | 1016 | kilograms |
| tons (long) | 2240 | pounds |
| tons (metric) | $10^{3}$ | kilograms |
| tons (metric) | 2205 | pounds |
| tons (short) | 907.2 | kilograms |
| tons (short) | 2000 | pounds |
| tons (short) per sq ft | 9765 | kgs per sq meter |
| tons (short) per sq ft | 13.89 | pounds per sq inch |
| tons (short) per sq ft | $1.406 \times 10^{6}$ | kgs per sq meter |
| tons (short) per sq in | 2000 | pounds per sq inch |
| Varas | 2.7777 | feet |

Table 10-10. Conversion factors (continued)

| MULTIPLY | BY | TO OBTAIN |
|---|---|---|
| watts | 0.05692 | BTU per min |
| watts | $10^7$ | ergs per second |
| watts | 44.26 | foot—pounds per min |
| watts | $1.341 \times 10^{-3}$ | horsepower |
| watts | $10^2$ | kilowatts |
| watt—hours | 3.415 | BTU |
| weeks | 168 | hours |
| yards | 91.44 | centimeters |
| yards | 3 | feet |
| yards | 36 | inches |
| yards | 0.9144 | meters |

**NOTE:** See FM 5-35 for additional conversion factors.

## English Metric

Table 10-11. Conversion English metric system

| ONE UNIT (BELOW) ↓ EQUALS → | MM | CM | METERS | KM |
|---|---|---|---|---|
| MM (Millimeters) | 1. | 0.1 | 0.001 | 0.000.001 |
| CM (Centimeters) | 10. | 1. | 0.01 | 0.000.01 |
| Meters | 1.000. | 100. | 1. | 0.001 |
| KM (Kilometers) | 1.000.000. | 100.000. | 1.000. | 1. |

| ONE UNIT (BELOW) ↓ EQUALS → | GM | KG | METRIC TON |
|---|---|---|---|
| GM (Gram) | 1. | 0.001 | 0.000.001 |
| KG (Kilograms) | 1.000. | 1. | 0.001 |
| Metric Tons | 1.000.000. | 1.000. | 1. |

UNITS OF CENTIMETERS

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CM | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 0.10 |
| Inch | 0.04 | 0.08 | 0.12 | 0.16 | 0.20 | 0.24 | 0.28 | 0.31 | 0.35 | 0.39 |

FRACTIONS OF AN INCH

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Inch | 1/16 | 1/8 | 3/16 | 1/4 | 5/16 | 3/8 | 7/16 | 1/2 |
| CM | 0.16 | 0.32 | 0.48 | 0.64 | 0.79 | 0.95 | 1.11 | 1.27 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Inch | 9/16 | 5/8 | 11/16 | 3/4 | 13/16 | 7/8 | 15/16 | 1 |
| CM | 1.43 | 1.59 | 1.75 | 1.91 | 2.06 | 2.22 | 2.38 | 2.54 |

Table 10-11. Conversion - English metric system (continued)

**LENGTH**

INCHES → CENTIMETERS
CM → INCHES
FEET → METERS
METERS → FEET
YARDS → METERS
METERS → YARDS
MILES → KILOMETERS
KM → MILES

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.62 | 1.61 | 1.09 | 0.91 | 3.28 | 0.30 | 0.39 | 2.54 |
| 2 | 1.24 | 3.22 | 2.19 | 1.83 | 6.56 | 0.61 | 0.79 | 5.08 |
| 3 | 1.86 | 4.83 | 3.28 | 2.74 | 9.84 | 0.91 | 1.18 | 7.62 |
| 4 | 2.49 | 6.44 | 4.37 | 3.66 | 13.12 | 1.22 | 1.57 | 10.16 |
| 5 | 3.11 | 8.05 | 5.47 | 4.57 | 16.40 | 1.52 | 1.97 | 12.70 |
| 6 | 3.73 | 9.66 | 6.56 | 5.49 | 19.68 | 1.83 | 2.36 | 15.24 |
| 7 | 4.35 | 11.27 | 7.66 | 6.40 | 22.97 | 2.13 | 2.76 | 17.78 |
| 8 | 4.97 | 12.87 | 8.75 | 7.32 | 26.25 | 2.44 | 3.15 | 20.32 |
| 9 | 5.59 | 14.48 | 9.84 | 8.23 | 29.53 | 2.74 | 3.54 | 22.86 |
| 10 | 6.21 | 16.09 | 10.94 | 9.14 | 32.81 | 3.05 | 3.93 | 25.40 |
| 20 | 12.43 | 32.19 | 21.87 | 18.29 | 65.62 | 6.10 | 7.87 | 50.80 |
| 30 | 18.64 | 48.28 | 32.81 | 27.43 | 98.42 | 9.14 | 11.81 | 76.20 |
| 40 | 24.85 | 64.37 | 43.74 | 36.58 | 131.23 | 12.19 | 15.75 | 101.60 |
| 50 | 31.07 | 80.47 | 54.68 | 45.72 | 164.04 | 15.24 | 19.68 | 127.00 |
| 60 | 37.28 | 96.56 | 65.62 | 54.86 | 196.85 | 18.29 | 23.62 | 152.40 |
| 70 | 43.50 | 112.65 | 76.55 | 64.00 | 229.66 | 21.34 | 27.56 | 177.80 |
| 80 | 49.71 | 128.75 | 87.49 | 73.15 | 262.47 | 24.38 | 31.50 | 203.20 |
| 90 | 55.92 | 144.84 | 98.42 | 82.30 | 295.28 | 27.43 | 35.43 | 228.60 |
| 100 | 62.14 | 160.94 | 109.36 | 91.44 | 328.08 | 30.48 | 39.37 | 254.00 |

Example: 2 inches = 5.08CM

**WEIGHT**

OUNCES → GRAMS
GRAMS → OUNCES
POUNDS → KILOGRAMS
KG → POUNDS
SHORT TON → METRIC TON
METRIC TON → SHORT TON

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 1.10 | 0.91 | 2.20 | 0.45 | 0.04 | 28.4 |
| 2 | 2.20 | 1.81 | 4.41 | 0.91 | 0.07 | 56.7 |
| 3 | 3.31 | 2.72 | 6.61 | 1.36 | 0.11 | 85.0 |
| 4 | 4.41 | 3.63 | 8.82 | 1.81 | 0.14 | 113.4 |
| 5 | 5.51 | 4.54 | 11.02 | 2.67 | 0.18 | 141.8 |
| 6 | 6.61 | 5.44 | 13.23 | 2.72 | 0.21 | 170.1 |
| 7 | 7.72 | 6.35 | 15.43 | 3.18 | 0.25 | 198.4 |
| 8 | 8.82 | 7.26 | 17.64 | 3.63 | 0.28 | 226.8 |
| 9 | 9.92 | 8.16 | 19.84 | 4.08 | 0.32 | 255.2 |
| 10 | 11.02 | 9.07 | 22.05 | 4.54 | 0.35 | 283.5 |
| 20 | 22.05 | 18.14 | 44.09 | 9.07 | 0.71 | 567.0 |
| 30 | 33.07 | 27.22 | 66.14 | 13.61 | 1.06 | 850.5 |
| 40 | 44.09 | 36.29 | 88.18 | 18.14 | 1.41 | 1,134.0 |
| 50 | 55.12 | 45.36 | 110.23 | 22.68 | 1.76 | 1,417.5 |
| 60 | 66.14 | 54.43 | 132.28 | 27.22 | 2.12 | 1,701.0 |
| 70 | 77.16 | 63.50 | 154.32 | 31.75 | 2.47 | 1,984.5 |
| 80 | 88.18 | 72.57 | 176.37 | 36.29 | 2.82 | 2,268.0 |
| 90 | 99.21 | 81.65 | 198.42 | 40.82 | 3.17 | 2,551.5 |
| 100 | 110.20 | 90.72 | 220.46 | 45.36 | 3.53 | 2,835.0 |

Example: 28 pounds = 9.07 kg + 3.63 kg = 12.70 kg

Table 10-11. Conversion - English metric system (continued)

| VOLUME | | | | | | |
|---|---|---|---|---|---|---|
| CU METERS → | | | | | CU FT → | CU YD |
| CU YD → | | | CU FT → | CU METERS | | |
| CU FT → | CU YD → | CU METERS | | | | |
| 1 | 0.037 | 0.028 | 27.0 | 0.76 | 35.3 | 1.31 |
| 2 | 0.074 | 0.057 | 54.0 | 1.53 | 70.6 | 2.62 |
| 3 | 0.111 | 0.085 | 81.0 | 2.29 | 105.9 | 3.92 |
| 4 | 0.148 | 0.113 | 108.0 | 3.06 | 141.3 | 5.23 |
| 5 | 0.185 | 0.142 | 135.0 | 3.82 | 176.6 | 6.54 |
| 6 | 0.212 | 0.170 | 162.0 | 4.59 | 211.9 | 7.85 |
| 7 | 0.259 | 0.198 | 189.0 | 5.35 | 247.2 | 9.16 |
| 8 | 0.296 | 0.227 | 216.0 | 6.12 | 282.5 | 10.46 |
| 9 | 0.333 | 0.255 | 243.0 | 6.88 | 317.8 | 11.77 |
| 10 | 0.370 | 0.283 | 270.0 | 7.65 | 353.1 | 13.07 |
| 20 | 0.741 | 0.566 | 540.0 | 15.29 | 706.3 | 26.16 |
| 30 | 1.111 | 0.850 | 810.0 | 22.94 | 1,059.4 | 39.24 |
| 40 | 1.481 | 1.133 | 1,080.0 | 30.58 | 1,412.6 | 52.32 |
| 50 | 1.852 | 1.416 | 1,350.0 | 38.23 | 1,765.7 | 65.40 |
| 60 | 2.222 | 1.700 | 1,620.0 | 45.87 | 2,118.9 | 78.48 |
| 70 | 2.592 | 1.982 | 1,890.0 | 53.52 | 2,472.0 | 91.56 |
| 80 | 2.962 | 2.265 | 2,160.0 | 61.16 | 2,825.2 | 104.63 |
| 90 | 3.333 | 2.548 | 2,430.0 | 68.81 | 3,178.3 | 117.71 |
| 100 | 3.703 | 2.832 | 2,700.0 | 76.46 | 3,531.4 | 130.79 |

Example: 3 cu yd = 81.0 cu ft

**Time**

Table 10-12. Time distance conversion

| MILES PER HOUR | KNOTS | FEET PER SECOND | KILOMETERS PER HOUR | METERS PER SECOND |
|---|---|---|---|---|
| 1 | 0.8684 | 1.4667 | 1.609 | 0.447 |
| 2 | 1.74 | 2.93 | 3.22 | 0.894 |
| 3 | 2.61 | 4.40 | 4.83 | 1.34 |
| 4 | 3.47 | 5.87 | 6.44 | 1.79 |
| 5 | 4.34 | 7.33 | 8.05 | 2.24 |
| 6 | 5.21 | 8.80 | 9.66 | 2.68 |
| 7 | 6.08 | 10.27 | 11.27 | 3.13 |
| 8 | 6.95 | 11.73 | 12.87 | 3.58 |
| 9 | 7.82 | 13.20 | 14.48 | 4.02 |
| 10 | 8.68 | 14.67 | 16.09 | 4.47 |
| 15 | 13.03 | 22.00 | 24.14 | 6.71 |
| 20 | 17.37 | 29.33 | 32.19 | 8.94 |
| 25 | 21.71 | 36.67 | 40.23 | 11.18 |
| 30 | 26.05 | 44.00 | 48.28 | 13.41 |
| 35 | 30.39 | 51.33 | 56.33 | 15.64 |
| 40 | 34.74 | 58.67 | 64.37 | 17.88 |
| 45 | 39.08 | 66.00 | 72.42 | 20.12 |
| 50 | 43.42 | 73.33 | 80.47 | 22.35 |
| 55 | 47.76 | 80.67 | 88.51 | 24.59 |
| 60 | 52.10 | 88.00 | 96.56 | 26.82 |
| 65 | 56.45 | 95.33 | 104.61 | 29.06 |
| 70 | 60.79 | 102.67 | 112.65 | 31.29 |
| 75 | 65.13 | 110.00 | 120.70 | 33.53 |
| 100 | 86.84 | 146.67 | 160.94 | 44.70 |

## Vehicle Dimensions and Classifications

Table 10-13. Vehicle dimension and classification

| NOMENCLATURE | HEIGHT (IN) | WIDTH (IN) | LENGTH (IN) | MILITARY LOAD CLASS (C) | MAX SPEED (MPH) |
|---|---|---|---|---|---|
| AVLB | 200 | 158 | 439 | 59 | 30 |
| Carrier, Cargo 6-ton, M548 | 116 | 110 | 248 | 13 | 43 |
| Carrier, Command Post, M577A1 | 106 | 106 | 226.5 | 13 | 8 |
| Carrier, Mortar, 81MM, M125A1 | 86.5 | 106 | 191.5 | 13 | 40 |
| Carrier, Mortar, 107MM, M106A1 | 86.5 | 113 | 194 | 14 | 40 |
| Carrier, Personnel, M113A2 | 86.5 | 106 | 191.5 | 13 | 40 |
| Cavalry, Fighting Vehicle, M3 | 118 | 126 | 258 | 24 | 45 |
| Crane, Boom, 20-ton RT | 163 | 128 | 522 | 30 | 35 |
| Crane, 25 ton Hydraulic MT 250 | 118 | 97 | 542 | 31 | 45 |
| Dozer, D7 w/blade | 120 | 137 | 230 | 28 | 6.2 |
| Howitzer, 155MM (SP), M109A3 | 130 | 143 | 355 | 28 | 35 |
| Howitzer, 8 in (SP), M110A2 | 135 | 140 | 392 | 29 | 32 |
| Infantry Fighting Vehicle, M2 | 118 | 126 | 258 | 24 | 45 |
| Improved Tow Vehicle M2 | 132 | 106 | 180 | 13 | 42 |
| Loader, Scoop, 2 1/2 C7, w/o roll cage | 102 | 102 | 300 | 20 | — |
| MLRs | 108 | 115 | 274 | 27 | 36 |
| M992 CATV (FAAS V) | 127 | 125 | 269 | 28 | 35 |
| Tank, Combat 105MM, M1 | 118 | 145 | 332 | 60 | 45 |
| Tank, Combat 105MM, M48A5 | 129.5 | 143 | 325 | 54 | 30 |
| Tank, Combat 105MM, M60A1 | 129.5 | 143 | 325 | 54 | 30 |
| Tank, Combat 105MM, M60A2 | 130.5 | 143 | 300.5 | 57 | 30 |
| w/Mine Roller (10-ton) | 130.5 | 160 | 439 | 79 | 5 |
| Tank, Combat 105MM, M60A3 | 130 | 143 | 325 | 55 | 30 |
| Trailer, Low Bed, 25-ton, M172 | 67 | 115 | 416 | 9 | — |
| Trailer, Water (400 gal), M149 (w/o water) | 76.5 | 82.5 | 83 | 4 | — |
| Truck, Ambulance, 1/4-ton, M713 | 77 | 71 | 143 | 3 | 65 |
| Truck, Ambulance, 1 1/2 ton, M792 | 91 | 84 | 227 | 5 | 55 |
| Truck, Cargo (HEMTT) M977 | 108 | 97 | 403 | 16 | 55 |
| Truck, Cargo, 1 1/4-ton, M880 | 95 | 85 | 221 | 4 | 60 |
| Truck, Cargo, 2 1/2-ton, M35A2 | 112 | 96 | 278.5 | 8 | 56 |
| Truck, Cargo, 5-ton 6x6, M54A2 | 116 | 97 | 315 | 15 | 54 |
| Truck, Cargo, 8-ton 4x4, M520 | 134 | 108 | 384 | 21 | 30 |
| Truck, Dump, 5-ton 6x6, M930 | 111 | 98 | 282 | 17 | 30 |
| Truck, Fuel (2,500 gal), M559 | 134 | 108 | 391 | 23 | 30 |
| Truck, Tanker (HEMTT), M978 | 108 | 97 | 403 | 15 | 55 |
| Truck, Tractor, 20-ton, M920 | 144 | 132 | 320 | 15 | — |
| Truck, Utility, 1/4-ton, M151A2 | 71 | 64 | 133 | 3 | 65 |
| Truck, Wrecker, 5-ton 6x6, M816 | 114 | 98 | 356 | 18 | 52 |
| Truck, Wrecker, 10-ton 4x4, M553 | 134 | 108 | 401 | 23 | 30 |
| Vehicle, Cmbt Earth Mover, M9 | 110 | 150 | 246 | 18 | 30 |
| Vehicle, Cmbt Engineer, M728 (CEV) | 128 | 146 | 351 | 57 | 30 |
| Vehicle, (light) Recovery, M578 | 130.5 | 124 | 250 | 25 | 37 |
| Vehicle, (med) Recovery, M88A1 | 123.5 | 135 | 325.5 | 55 | 31 |

NOTE: Military load classification is for laden cross country or off highway (C).

## Expedient Vehicle Classification

In an emergency temporary vehicle classification can be accomplished by using expedient classifcation methods. The vehicle should be reclassified by the analytical method as outlined in TM 5-312 or by reference to FM 5-36 as soon as possible to obtain a permanent classification number.

**Wheeled.** Expedient classification for wheeled vehicles may be accomplished by the following methods:

- Compare the wheel and axle loadings and spacings of the unclassified vehicle with those of a classified ified vehicle of similar design and then assign a temporary class number.
- Assign a temporary class number using the formula:

TEMPORARY CLASS (wheeled vehicles = 0.85 $W_T$

Where: $W_T = \frac{A_T P_T N_T}{2,000}$

and $W_T$ = gross weight of of vehicle in tons
$A_T$ = average tire contact area in square inches (tire in contact with hard
= surface
$P_T$ = tire pressure in psi
$N_T$ = number of tires

NOTE: The tire pressure may be assumed to be 75 psi for 2½-ton vehicles or larger no tire gage is available. For vehicles having unusual load characteristics or odd axle spacings, a more deliberate vehicle classification procedure as outlined in STANAG 2021 is required.

**Tracked** . Expedient classification for tracked vehicles may be accomplished by the following methods:

- Compare the ground contact area of the unclassified tracked vehicle with that of a previously classified vehicle to obtain a temporary class number.
- Assign a temporary class number using the formula.

TEMPORARY CLASS (ltracked vehicles) = $W_T$

Where $W_T$= gross weight in tons

The gross weight of the tracked vehicle ($W_T$) can be estimated by measuring the total ground contact area of the tracks (square feet and equaling this to the gross weight in tons.

Example: An unclassifed tracked vehicle has a ground contact area of 5.500 square inches. Therefore, the area is about 38.2 square feet, and the class of the vehicle is 38.2 or 39, since ground contact area in square feet equals the aproximate weight of a tracked vehicle in tons which is approximately equal to class number.

**Nonstandard combinations.** The class number of nonstandard combinations of vehicles may be obtained expeditiously as follows:

Combination class = 0.9 (A + B) if A + B ≤ 60
Combination class = A + B if A + B > 60
A = Class of first vehicle
B = Class of second vehicle

**Adjustment for other than rated load.** An expedient class may be given to overloaded or under loaded vehicles by adding 10 or subtracting the difference in loading in tons from the normally assigned vehicle class. The expedient classification number is marked with a standard vehicle class sign to indicate temporary class ification as shown in Firgure 10-1.

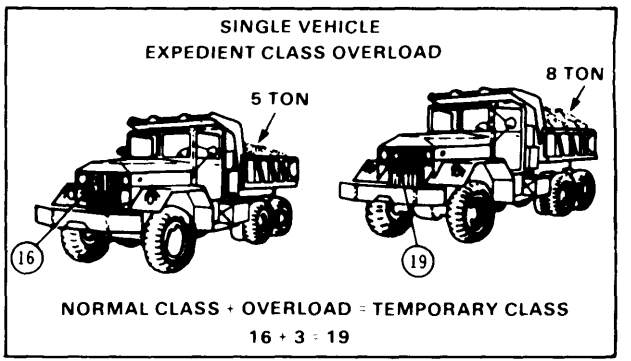



Figure 10-1. Expedient class overload

## Weapons Systems Characteristics

Table 10-14. Infantry weapons

| WEAPON | UNLOADED WEIGHT LB | TYPE OF FEED | METHOD OF OPERATION | CYCLIC (C)/ OR MAX (M) RATE OF FIRE | MAX/MAX EFFECTIVE RANGE (METERS) | AMMUNITION PACK | AMMUNITION WEIGHT (LB) (PACKED) | BASIC LOAD OF AMMO PER SOLDIER WPN | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Pistol M1911A1 Cal 45 | 2 1/2 | 7 Rd Magazine | Recoil semiauto | 35-42 (M) | 1,500/50 | 50 Rds/Box 20 Box/Can 2 Cans/Case | 113 | 21 | |
| Rifle M14 M14 A1 7.62MM | 9.84 12.12 | 20 Rd Magazine | Gas semiauto and auto | 700-750 (C) | 3,725/460 3,725/700 (SA) /460 (A) | 5 Rd Clip 12 Clips/Band 7 Band/Can 2 Cans/Case | 69 | 160 160/760 | Selector must be installed bipod available when used as automatic rifle |
| Rifle M16 A2 5.56MM | 6 1/2 | 30 Rd Magazine | Gas semiauto and auto | 700-800 | 2,653/460 | 10 Rd Clips 14 Clips/Band 6 Band/Can 2 Cans/Case | 85 | 210 | May be issued with a bipod when used as automatic rifle |
| Saw Squad Automatic Weapon | 22.0 | 200 Rd Links and M16 Magazine | Belt or magazine fed-gas operated | 725 RPM | 1,000/800 | 200 Linked Box (rds) M16 Magazine | 9.5 | 600 | Most accuracy firing from prone position with the tripod |
| Machine gun M60 7.62MM | 23 | Belt-metallic split link | Gas auto | 550 (C) | 3,725/1,100 | 220/Belt 1 Belt/Can 4 Cans/Box | 75 | 2,200 | Effective range based on gunners ability |
| Machine gun HB, M2 Cal | MG 84 MT-44 | Belt-metallic split link | Recoil semiauto and auto | 450-500 | 6,000/725 AA /1,830 gnd | 105/Belt 1 Belt/Can 2 Cans/Case | | 2,100/wpn | Used in antiaircraft or ground role |
| Shotgun riot type 12 gage pump | 7 1/2 | 5 Rd Tube | Manual (pump) | 5 | Depends on type of shot | 12 Carton 20 Carton/Case | 45 | 10 | |
| Grenade launcher M79/M203 40MM | 6.3 | Single shot | Percussion | 2-4 | 400/150-ft tgt /250-area tgts | 12/Band 12 Band/Box | 9/Bandoleer | 30 | Minimum safe range: Combat 31M Trng 80M Arm distance: 14-28M Effective burst radius 5M |

Table 10-14. Infantry weapons (continued)

| WEAPON | UNLOADED WEIGHT LB | TYPE OF FEED | METHOD OF OPERATION | CYCLIC (C) OR MAX (M) RATE OF FIRE | MAX/MAX EFFECTIVE RANGE (METERS) | AMMUNITION PACK | AMMUNITION WEIGHT (LB) (PACKED) | BASIC LOAD OF AMMO PER SOLDIER WPN | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| MAW M47 medium antitank Dragon | 31.9 | Single shot | Recoilless auto rifle | 1 | 1,000 | | 25.2 | By TOE | Back blast danger zone 30M Caution zone 20M |
| M57 90MM Recoilless Rifle | 37.5 | Single shot | Recoilless semiauto | 1 | Stationary target 2,100 300M moving target 2,100 200M | Canister antitank antipersonnel | | By TOE | Back blast danger zone 28M Caution zone 15M |
| Hand Grenade Frag M67 M68 WP M34 | 1 1 1 1/2 | | Electrical impact fuze 4-6 sec delay | | Approx 25M depen dent on throwing distance of individual | 1/Ctn 20 Ctns/Box | 2/Grenade | 4 | Bursting Radius 15M 15M 25M (60 sec burn time) |
| Mine antipersonnel M18 A1 Claymore | 3.5 | | Controlled electric or tripwire detonation | One shot | 250/50 | 1/Kit (com plete) 6 Kits/Ctn | 6.8 | 10 Non-Div Engr Bn 2 Track Veh (Mech Div Engr Bn) 15 Div Engr Bn | When employed with tripwire must be treated as a mine and its location re corded and reported Directional frag 60 sector with 50M radius. 16M lethal zone (back and sides) and 100M back blast danger zone |
| Rocket Heat M72A1 (LAW) 66MM | 4.7 | Single shot throw away | Manual | 1 shot | 1,000/200 | 5/Ctn 3 Ctns/Box | 27 1/2 120 | By TOE | Back blast area 15M danger zone 25M caution zone Front site graduated to 225M M72 issued as ammunition Weight is load |

Table 10-14. Infantry weapons (continued)

| WEAPON | UNLOADED WEIGHT LB | TYPE OF FEED | METHOD OF OPERATION | CYCLIC (C)/ OR MAX (M) RATE OF FIRE | MAX/MAX EFFECTIVE RANGE (METERS) | AMMUNITION PACK | AMMUNITION WEIGHT (LB) (PACKED) | BASIC LOAD OF AMMO PER SOLDIER WPN | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Rocket Launcher M202 and M202 A1 4 Tube 66MM (FLAME) | 11.5 | 4 Rd Clip | Recoilless semiauto | 1 clip | 200 pt tgts<br>750/area tgts<br>20 minimum | 4 Rds/Clip<br>4 Clips/Box | 15.1 ea<br>122 | | M74 rocket is a flame encapulated rd. 5.5-13M arming range. Bursting radius 20M. Back blast zone 40M |
| Portable Flame Thrower ABC. M9-7 | 25 | Fuel propel-led by gas under pressure | Manual | 5-8 seconds continuous | 40-50 | 4 gal of thickened fuel | 25 | Ignition cyl-8. Peptizer-1 gal thickener-10 lb | |
| Self-propel-led Flame Thrower M132 A-1 | 21,000 | Fuel propel-led by gas under pressure | Electrical | 32 seconds for continous discharge | 150-170 | 200 gal of thickened fuel | 1,260 | | Includes weight of M113 personnel carrier |
| Mortar M29. with mount M23 A2 81MM | Barrel 28<br>Bipod 40<br>Sight 4<br>Base 26 | Muzzle loading by hand | Drop fire | 12 (M) for 2 min | 4,512/4,512 | 1/per carton<br>4 ctns/box | 20 ea | 120 | Effective bursting area: 25 x 20M |
| Mortar M30. with mount M24 A1 4-2 in | Barrel 157<br>Bridge 170<br>Base 193<br>Standard 60<br>Rotator 90 | Muzzle loading by hand | Drop fire | 18 (M) for 1 min or 9 per min for 5 min | 920 minimum<br>5,650/5,650 max | 1 rd/per ctn<br>HE illum<br>smoke gas | 27<br>26<br>28<br>24 | 160 | 40 x 20<br>40-90 seconds<br>WP<br>H, HD, and HT |

Table 10-15. US tank weapons

| WEAPON | WEIGHT (TONS) | MAX SPEED (MPH) | MAX SPEED (KPH) | CRUISING RANGE (MILES) | CRUISING RANGE (KILOMETERS) | ROUNDS ABOARD | TYPE AMMO | MAX OPEN DIRECT FOR RANGE (METERS)* |
|---|---|---|---|---|---|---|---|---|
| 105-MM Gun Tank, M1 | 60 | 45 | 72 | 275 | 440 | 55 | | |
| 105-MM Gun Tank, M60A1 | 53 | 30 | 48 | 310 | 500 | 63 | APDS-T | 3,000 |
| | | | | | | | APFSDS-T | 4,000 |
| | | | | | | | HEAT-T | 4,000 |
| 105-MM Gun Tank, M48A5 | 54 | 30 | 48 | 310 | 500 | 43 | HEP-T | 1,200 Point Tgt |
| | | | | | | | | 3,600 Area Tgt |
| | | | | | | | WP-T | 1,200 Point Tgt |
| | | | | | | | | 3,600 Area Tgt |
| | | | | | | | APERS-T | 200-4,000 |
| 152-MM Gun Tank, M60A2 | 57.2 | 30 | 48 | 280 | 451 | 48 | Missile | 3,000 |
| | | | | | | Msl-Conv | Cannister | 400 |
| | | | | | | 13 33 | HEAT-MP | 1,600 Hard Tgt |
| | | | | | | | | 2,900 Area Tgt |
| 165-MM Gun Tank, M728 (engr cbt veh) | 57 | 30 | 48 | 280 | 451 | 30 | HEP-T | 1,000 |

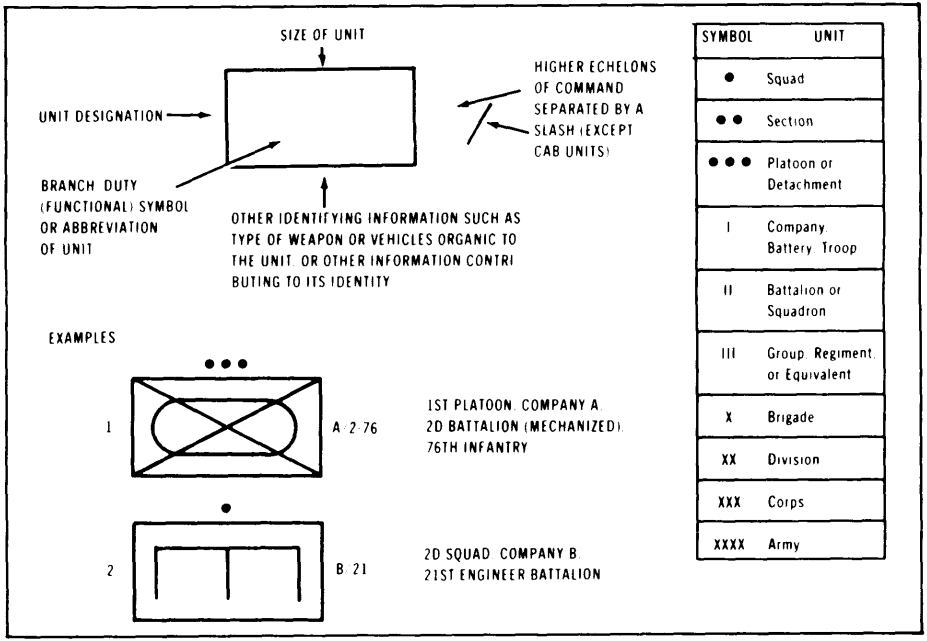
Table 10-16. US Antiarmor missiles

| MISSILE | PRIME MOVER | WEIGHT (LB) | GUIDANCE LINKAGE | ROUNDS ABOARD | RANGE (METERS) |
|---|---|---|---|---|---|
| Shillelagh | M60A2 Tank | 61.3 (round only) | Infrared | 13 | 3,000 max<br>800 min |
| TOW | M113A1 Guided Missile Carrier or Improved TOW Vehicle (ITV) | 40 (round only) | Wire | 10 | 3,000 max<br>65 min |
| | AH-1S Atk Hel | | | 8 | 3,750 max<br>65 min |
| Dragon | Individual Soldier or | 32 (carry weight) 25.2 | Wire | 6 | 1,000 max |
| | Mounted on M113A1 | (round only) | | | 65 min |

Table 10-17 US field artillery and air defense weapons

| WEAPON | RDS ON VEH | RDS ON CARRIER | RANGE METERS | WEIGHT POUNDS | TIME TO EMPLACE MIN | MAX RATE OF FIRE NO OF RDS FIRST 3 MIN | SUSTAINED FIRE RDS PER HR | NO OF WEAPONS PER UNIT | AMMUNITION TYPES | AMMUNITION FUZES |
|---|---|---|---|---|---|---|---|---|---|---|
| 105 MM How Towed M102 | Sit Dep | NA | 11 500 | 3.170 | 2 | 30 | 180 | Inf Div. Airborne/Air Assault Div. Corps Bn 18 | WP. HE. HEAT. CML. Illum. SMK. ICM. APERS. HEP | Quick. Delay VT. Time Concrete Piercing |
| 155 MM How Towed M114A1 A2 | 48 | NA | 14 600 | 12.700 | 3 5 | 12 | 60 | Inf Div Bn. Corps Bn 18 | FASCAM HE WP | |
| 155 MM How SP M109A1 | 28 | 96 | 18 100 24 000 (RAP) | 53.940 | 0 5 | 12 | 60 | Armd and Mech Div Bn. Corps Bn 18 | CML Illum SMK | Quick Delay VT |
| 155 MM How SP M109A2/A3 | 36 | 96 | 18.000 24.000 (RAP) | 53.940 | 0.5 (RAP) | 12 | 20 | Armd and Mech Bn Corps Bn 18 | Nuc ICM RAP | Time Concrete Piercing |
| 155-MM How Towed M198 | 48 | NA | 24.000 30.000 (RAP) | 15.500 | 5 | 12 | Variable | TBD | CLGP | |
| 8 Inch How SP M102A2 | 2 | 36 | 22 900 30.000 (RAP) | 62 500 | 2 5 | 4 5 | 30 | Inf Div Btry 4 Armd/Inf Div Bn. Corps Bn-12 | HE Nuc CML ICM SPOT | Quick Delay VT. Time Concrete Piercing |
| Vulcan CM 741 | 2 100 | 4.200 | 1.200 AD 4.500 Surface | 26.000 | NA | 3.000 | NA | Bn-24 | HEI HEIT SD | PD |

Table 10-18. Unit symbols




| SYMBOL | UNIT |
|---|---|
| ● | Squad |
| ●● | Section |
| ●●● | Platoon or Detachment |
| I | Company Battery Troop |
| II | Battalion or Squadron |
| III | Group Regiment or Equivalent |
| X | Brigade |
| XX | Division |
| XXX | Corps |
| XXXX | Army |

Table 10-19. Unit identification symbols

| | |
|---|---|
| Airborne | |
| Air Defense | |
| Airmobile | |
| Antiarmor | |
| Armor | |
| Armored Cavalry | |
| Army Aviation | |
| Attack Helicopter | |
| Bridging | |
| Cavalry or Reconnaissance | |
| Chemical | |
| Engineer | |
| Field Artillery | |

Table 10-19 Unit identification symbols (continued)

| | |
|---|---|
| Infantry | |
| Light | LT |
| Maintenance | |
| Mechanized | |
| Medical | |
| Military Police | MP |
| Mountain | |
| Petroleum Supply | |
| Quartermaster | |
| Signal/Communications | |
| Transportation | |



## Obstacles

Obstacles are divided into four types - point, demolitions, linear, and minefields. The following obstacle indicators can be superimposed on either point or linear obstacle symbols. (More detailed symbology is required for use by engineers and low level tactical commanders, and also for use in target folders, minefield records, and instructional manuals.)

Table 10-20 Obstacle symbols

| DESCRIPTION | SYMBOL |
|---|---|
| Abatis | |
| Booby trap | |
| Ac or antiairborne obs | |
| Demolitions | |
| Planned target demolition | |
| Prepared demolition state 1 (safe) (passable) | |
| Prepared demolition state 2 (passable) | |
| Fired demolition | |
| Road block completed | |
| Proposed rd br dml | |
| Atomic demolition | |
| Linear | |
| Antitank ditch (A rectangle need not be used when the obstacle is drawn to scale on the overlay. Teeth point toward the enemy.) | Planned / Completed |
| Unspecified | |
| Minefields | |
| Indicators Antipersonnel mine | |

Table 10-20 Obstacle symbols (continued)

| | |
|---|---|
| Antipersonnel mine connected to tripwire | |
| Rows of antipersonnel mines | |
| Antitank mine | |
| Row of antitank mines | |
| Antitank mine with antihandling device | |
| Directional mine (arrow points in direction of main effect) | |
| Mine cluster | |
| Mine, type unspecified | |
| Conventional | |
| A planned minefield consisting of unspecified mines | |
| A completed minefield consisting of unspecified mines | |
| Scatterable minefield (DTGs used for self-destruct mines) | S DTG |
| Conventional minefield thickened with scatterable mines | S DTG |
| Conventional row mining (outline drawn to scale) | |

Table 10-20 Obstacle symbols (continued)

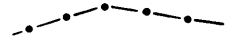
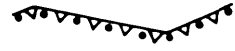
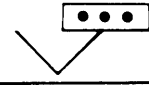
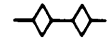
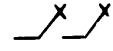
| | |
|---|---|
| **Nuisance** | |
| Nuisance minefield | |
| **Phony** | |
| Phony minefield | |
| **Protective** | |
| Protective minefield |  |
| Antitank ditch reinforced with antitank mines |  |
| **Tactical** | |
| Tactical minefield of scatterable antitank mines, effective till 101200Z | |
| Completed antitank minefield (drawn away from the location and connected by a vector) |  |
| Antitank obs, type unspecified |  |
| Stakes, roll, antitank ditch, or similar obs |  |
| Tetrahedron, dragon's teeth and other similar obs;<br>a. Fixed | |
| b. Fixed and prefabricated | |
| c. Movable | |
| d. Movable and prefabricated | |
| Antitank obs consisting of ditch, wall, and stakes | |

Table 10-20 Obstacle symbols (continued)

| | |
|---|---|
| Strong point | |
| Fortified area | |
| Demolished area | |
| Inundation | |
| Underwater obs (booby traps) | |
| Wire:<br>a. Unspecified type | XXXXX |
| b. Concertina, single | |
| c. Concertina, multiple | |
| d. Single fence | |
| e. Double fence | |
| f. Double apron fence | |
| g. Low wire fence | |
| h. High wire fence | |

Table 10-20 Obstacle symbols (continued)

| | |
|---|---|
| Tripwire | |
| Crossings | |
| Assault | |
| Ferry | |
| Ford | |
| Ford with difficulty | |
| Gap or bridge | |
| Lane | |
| Raft site | |
| | |
| | |
| | |
| | |
| | |

Table 10-21. Weapon symbols

| | LIGHT | MEDIUM | HEAVY |
|---|---|---|---|
| Air defense gun | | | |
| Antitank gun | | | |
| Antitank missile, self-propelled | | | |
| Antitank rocket launcher | | | |
| Flamethrower | portable | vehicular | |
| Gun in air defense role, self-propelled | | | |
| Gun in antitank role | | | |
| Howitzer | | | |
| Machine gun - automatic weapon | | | |
| Mortar | | | |
| Multibarrel rocket launcher | | | |
| Surface-to-air missile | | | |
| Surface-to-surface missile | | | |

# GLOSSARY

## Acronyms and Abbreviations

| | |
|---|---|
| **A** | armed |
| **ACE** | armored combat earthmover |
| **ADAM** | Area Denial Artillery Munition |
| **ADE** | Assistant Division Engineer |
| **ADM** | atomic demolitions munition |
| **AHD** | antihandling device |
| **AM** | amplitude modulation |
| **AP** | antipersonnel mine |
| **APB** | antipersonnel blast mine |
| **APC** | armored personnel carrier |
| **APF** | antipersonnel fragmentation |
| **approx** | approximate |
| **AR** | angle of response |
| **armd** | armored |
| **AT** | antitank mine |
| **ATD** | antitank ditch |
| **AVLB** | armored vehicle launched bridge |
| **bde** | brigade |
| **BEB** | bridge erection boat |
| **BEB-SD** | bridge erection boat shallow draft |
| **BIFV** | Bradley infantry lighting vehicle |
| **bn** | battalion |
| **°C** | Celcius |
| **$C^3$** | command, control communications |
| **CAB** | combat aviation brigade |
| **cav** | cavalry |
| **CBR** | California Bearing Ratio |
| **C bt** | combat |
| **CEO** | Communications Operation |
| **CEOI** | Communications-Electronics Operations Instructions |
| **CEV** | combat engineer vehicle |
| **CFA** | covering force area |
| **CLAMS** | Cleared Lane Marking System |
| **cm** | centimeter(s) |
| **co** | company |
| **CP** | command post |
| **CPR** | cardiopulmonary resuscitation |
| **div** | division |
| **D/R** | deck/roadway |
| **DS** | double story |
| **DTG** | date-time group |
| **DZ** | drop zone |
| **EEI** | essential elements of information |
| **EENT** | early evening nautical twilight |
| **EM** | enlisted member |
| **engr** | engineer |
| **ENGREP** | engineer report |
| **ERP** | engineer release point |
| **°F** | Fahrenheit |
| **FASCAM** | Family of Scatterable Mines |
| **FDC** | fire direction center |
| **FEBA** | forward edge of battle area |
| **FLOT** | forward line of troops |
| **FM** | frequency modulated |
| **FO** | forward observers |
| **fps** | feet per second |
| **FS** | far shore |
| **FSCL** | fire support coordination line |
| **FSO** | fire support officer |
| **ft** | foot, feet |
| **gal** | gallon(s) |
| **GEMSS** | Ground Emplaced Mine Scattering System (M128) |
| **gm** | gram |
| **GPBTO** | general purpose barbed tape obstacle |
| **GS** | general support |
| **GTA** | graphic training aid |

| | |
|---|---|
| **HC** | hydrogen chloride |
| **HDP** | hull defilade position |
| **HEMMS** | hand emplaced minefield marking set |
| **HP** | horsepower |
| **HQ** | headquarters |
| **hr** | hour(s) |
| **IAW** | in accordance with |
| **in** | inch (es) |
| **inf** | Infantry |
| **IOE** | irregular outer edge |
| **IPS** | Improved Plough Steel |
| **IRD** | "engineer reconnaissance patrol" (Threat term) |
| **kg** | kilogram |
| **km** | kilometer(s) |
| **kmph** | kilometers per hour |
| **ksi** | kips per square inch |
| **LAW** | light antitank weapon |
| **lb** | pound(s) |
| **LD/LC** | line of departure line of coordination |
| **LOC** | lines of communications |
| **LP** | listening post |
| **LRS** | link reinforcement set |
| **LTR** | light tactical raft |
| **LZ/DZ** | landing zone/drop zone |
| **m** | meter(s) |
| **MBA** | Main Battle Area |
| **mech** | mechanical |
| **MEDEVAC** | medical evacuation |
| **METT-T** | mission, enemy, terrain and weather, time and troops |
| **MOPMS** | Modular Pack Mine System (XM133) |
| **MOPP** | mission oriented protection posture |
| **MOS** | minimum operating strip |
| **MOUT** | military operations on urbanized terrain |
| **mph** | miles per hour |
| **mps** | meters per second |
| **MRB** | motorized rifle battalion |
| **MRD** | motorized rifle division |
| **MRR** | motorized rifle regiment |
| **mt** | metric ton |
| **$m^2$** | square meters |
| **N** | north |
| **NBC** | nuclear, biological, chemical |
| **NCO** | noncommissioned officer |
| **NCOIC** | noncommissioned officer in charge |
| **MF** | minefield |
| **MGB** | medium girder bridge |
| **MICLIC** | Mine Clearlng Line Charge (M58A3) |
| **min** | minute |
| **MLC** | military load classification |
| **mm** | millimeter (s) |
| **NS** | near shore |
| **NTZ** | nontouch zone |
| **OBM** | outboard motor |
| **OCOKA** | observation and fields of fire, cover and concealment, obstacles, key terrain and avenues of approach |
| **OIC** | officer in charge |
| **OIR** | other intelligence requirements |
| **OOD** | "movement support detachment" (Threat term) |
| **OP** | observation post |
| **OPCON** | operational control |
| **OPLAN** | operation plan |
| **OPORD** | operation order |
| **OPSEC** | operational security |
| **ORP** | objective rally point |
| **OT** | observer target |

| | |
|---|---|
| **PIR** | priority intelligence requirements |
| **PL** | phase line |
| **plt** | platoon |
| **POL** | petroleum, oils, and lubricants |
| **POZ** | "mobile obstacle detachment" (Threat term) |
| **ppm** | parts per million |
| **RAAMS** | Remote Antiarmor Mine System |
| **ROBAT** | Robatic Obstacle Breaching Assault Tank |
| **RP** | reference point |
| **RTO** | radio transmitter operator |
| **S** | south/safe |
| **SALUTE** | size, activity, location, unit time, and equipment |
| **SCATMINWARN** | Scatterable Minefield Warning |
| **SD** | self destruct |
| **SEE** | Small Emplacement Excavator |
| **SOP** | standing operating procedures |
| **SS** | single story |
| **STANAG** | Standardization Agreement |
| **STB** | super tropical bleach |
| **TB** | tank battalion |
| **TD** | tank division |
| **TDP** | turret defilade position |
| **TEXS** | Tactical Explosive System |
| **TM** | technical manual |
| **TOC** | tactical operation center |
| **TOE** | table(s) of organization and equipment |
| **TOW** | tub-launched optically tracked, wire guided missile |
| **tp** | troop |
| **TR** | tank regiment |
| **US** | United States |
| **VT** | variable time |
| **WP** | white phosphorous |
| **wt** | weight |

**Symbols**

| | |
|---|---|
| ° | degree |
| **x** | times (formulas) |
| **+** | plus |
| **–** | minus |
| **÷** | divided by |
| **=** | equals |
| **'** | foot, feet |
| **''** | inch(es) |
| **#** | number |
| **&** | and |
| **%** | percent |
| **<** | less than |
| **>** | greater than |
| **≤** | less than or equal to |
| **≥** | greater than or equal to |
| **1st** | first |
| **2d** | second |
| **3d** | third |
| **∞** | infinity |

# INDEX


Abatis, 3-4, 6-6
Abutments, 1-8
Air defense weapons, 10-25
Aircraft characteristics, 2-23
Airfields
  Constructions, 2-25 - 2-27
  Dust control, 2-24
  Maintenance, 2-27
  Mat repairs, 8-12
  Mats, 8-10
  Repairs, 8-11 - 8-16
  Requirements, 2-24
Alarm (NBC), 1-20
Ambush, organization, 1-8
Anchorage systems, 7-13 - 7-20
Antennas, 1-38, 1-39
Antihandling devices, 3-44
Antitank
  Ditches, 3-12
  Weapons, 10-24
Antivehicular obstacles, 3-12 - 3-37
Areas
  Assembly, 1-4
  Bivouac, 1-4
  Dispersion, 1-3
  Of geometric figures, 10-10
Armored Combat Earthmover (ACE), 2-15
Armor Vehicle Launch Bridge (AVLB), 7-3
Army aircraft, 2-23
Army track road, 2-21
Artillery, 1-10 - 1-14
  Ammunition and fuzes, 1-14
  Equipment, 10-25
  Fire adjustment, 1-12
  Fire request, 1-10
  Smoke, 1-13
Assault
  Boats, 7-2
  Crossings equipment, 7-2 - 7-4
Assembly area, 1-4
Attachments, rigging, 9-1 - 9-7
Authentication, 1-40
Aviation, forward, 2-23
Bailey bridge, M2, 7-49 - 7-68
Bangalore torpedo, 2-4
Barbed wire
  Concertina, 3-8, 3-9, 3-11
  Entanglements, 3-6
  Minefield fencing, 3-4
  Obstacles, 3-7 - 3-11
  Portable obstacle, 3-11
  Requirements, 3-5
  Tanglefoot, 3-10
Bivouac areas, 1-4
Block and tackle, 9-8
Blister agent, 1-15
Blood agent, 1-15
Boom derrick, 9-7
Boulder blasting, 6-10

Breaching
Charge computation, 6-7 - 6-9
Charges, 6-7 - 6-9
Minefield, 2-5
Methods, 2-4
Obstacles, 2-5
Procedures, 2-15
Bridge anchorage system, 7-13 - 7-20
Bridge demolition
Abutment, 6-13, 6-14
Intermediates support, 6-13
Reconnaissance, 5-13
Superstructure 6-15 - 6-19
Bridge classification
Deliberate, 5-6
Hasty, 5-6
Reconnaissance, 5-6 - 5-13
Bridge fixed
Bailey, M2, 7-49 - 7-68
Hasty nonstandard (timber trestle), 7-68 - 7-73
Medium Girder Bridge (MGB), 7-30 - 7-48
M4T6 Fixed Span w/trestle, 7-20 - 7-29
M4T6 Fixed Span wo/trestle, 7-20 - 7-25
Bridge Floating
Class 60, steel, 7-10 - 7-11
Light Tactical Raft (LTR), 7-11, 7-12
M4T6 Float Bridge 7-8 - 7-10
Ribbon, 7-1 - 7-7
Bridge reconnaissance
Deliberate 5-6 - 5-13
Hasty, 5-6
Bridge reconnaissance (continued)
Report, 5-13
Symbols, 5-19, 5-21
Bridge, timber trestle
Classification, 5-6
Design, 7-68 - 7-73
Bridge, other
AVLB, 7-3
improvised, 7-68
Threat, 3-2
Bunkers, 4-15
Cables, anchorage system, 7-13 - 7-20
Call for Fire, 1-10
Camouflage, 4-18
Cardiopulmonary Resuscitation (CPR), 1-28
Chains, 9-2
Chemical agents, 1-15
Chespaling, 2-19
Clamps wire rope, 9-5
Class 60, steel bridge, 7-10, 7-11
Classification
Bridge, 5-6
Roads, 5-3
Routes, 5-1
Soil, 8-1 - 8-3
Vehicle, 10-19, 10-20
Claymore mines, 3-39, 3-51
Clearing
Lanes, 2-5
Minefields, 2-5
Routes, 2-6

Cluster, mine, 3-21
Cold weather injuries, 1-30
Combat Engineer Vehicle (CEV), 2-13, 2-14, 10-19
Combat orders, 1-1
  Operation, 1-2
  Warning, 1-1
Combat patrol, 1-7
Combat roads, 2-18
  Chespaling mats, 2-19
  Corduroy, 2-19
  Crater repair, 2-23
  Planning, 2-18
  Sand grid, 2-22
  Sommerfeld tracks, 2-21
  Tread roads, 2-20
  Wire mesh, 2-22
Communication equipment
  Antennas, 1-38, 1-39
  Radios, 1-37
Communication security, 1-40
Concertina roadblock, 3-10, 3-11
Concrete obstacle, 3-15
Conversion, English to Metric, 10-15 - 10-18
Conversion factors, 10-11 - 10-16
Corduroy roads, 2-19, 2-20
Counterforce charge, 6-10
Countermine, 2-3
Countermobility planning, 3-3
Crater repair, 2-23
CPR, 1-28
Cratering charges, 6-11
Crew-served weapon fighting position, 4-3
Culvert, 4-8, 8-6 - 8-8
Daily water requirement, 1-36
Decontamination, 1-27
Deep-cut position, 4-12
Defensive equipment, Threat, 2-2
Defensive position wire requirement, 3-6
Deliberate
  Bridge classification, 5-6 - 5-12
  Defensive position, 3-6
  Fighting positions 4-9, 4-10
  Protective minefield, 3-16
  River crossing, 7-1
  Threat minefield, 2-1
  Threat obstacle system, 2-1, 2-2
Demolition
  Abatis, 6-6
  Abutment, 6-13
  Blasting boulder, 6-7
  Breaching charge, 6-7 - 6-9
  Bridge, 6-13 6-19
  Charge calculations, 6-3
  Craterlng charge, 6-11, 6-12
  Ditching. See Cratering charges
  Expedient, 6-21
  Firing systems, 6-3
  Hasty, 6-21
  Obstacle breaching, 2-15
  Pier, 6-13

Demolition (continued)
Priming, 6-2
Reconnaissance, 6-20
Steel cutting, 6-4, 6-5
Stumping, 6-7
Timber cutting, 6-6
Wall breaching, 2-16
Design
Culvert, 8-6 - 8-8
Minefield, 3-16
Open ditch, 8-9
Detection mines, 2-3
Diamond charge, 6-5
Dismounted operations, 1-4 - 1-9
Movement techniques, 1-4, 1-5
Job site security, 1-6
Patrolling, 1-6 - 1-9
Ditches
Antitank, 3-12
Drainage, 8-9
Double apron fence, 3-7
Drainage, 8-4
Driftpins, 9-9
Dust control, 2-24
Earth moving equipment, 10-19
Electric
Firing systems, 6-3
Priming, 6-1
Wire table, 10-3, 10-4
Enemy Minefield Report, 2-3
Entanglements, 3-6
Engineer
Equipment (Threat), 2-2, 2-3, 3-2
Equipment (US), 2-4 2-14, 7-2 - 7-14
Reconnaissance, 5-17
Resource symbols, 5-21
Expedient
Airfield surfaces, 8-10
Bridging, 7-68
Culverts, 4-8, 8-6
Demolitions, 6-21
Mines, 3-49
Obstacles, 3-12 - 3-15
Road construction, 2-18
Road surfaces, 2-19 - 2-22
Explosive
Charateristics, 6-2
Obstacles, 6-12, 6-14
Relative effectiveness factor (RE), 6-2
Safe distance, 6-1
Safety, 6-1
Facing revetments, 4-14
FASCAM, 3-35
Fastenings, 9-5
Ferry reconnaissance, 5-20
Fiber rope, 9-3, 9-4
Field fortification, 3-3
Field sanitation, 1-35
Fighting position
Combat vehicles, 4-9
Crew-served weapons, 4-3
Individual, 4-1

Firing devices
Expedient, 3-54
US, 3-44 - 3-47
Firing systems, 6-3
First aid, 1-28
NBC, 1-15
Fixed bridge
Bailey, M2, 7-49 - 7-68
Hasty nonstandard, 7-68 - 7-73
Medium Girder Bridge (MGB), 7-30 - 7-48
M4T6 Fixed Span w/trestle, 7-20 - 7-29
M4T6 Fixed Span we/trestle, 7-20 - 7-25
Flame mines, 3-53
Float bridges
Class 60, steel, 7-10, 7-11
Light Tactical Raft (LTR), 7-11, 7-12
M4T6 Float Bridge, 7-8 - 7-10
Ribbon. 7-1 - 7-7
Floating equipment, 7-2 7-5 7-8, 7-10, 7-11
Ford reconnaissance, 5-16
Foreign mines
AP 2-9 - 2-12
AT 2-6 - 2-9
Forms
DA 1248, 5-4
DA 1249, 5-13
DA 1251, 5-16
DA 1355, 3-28 - 3-33
DA 1355-1R, 3-19
DA 1711-R, 5-18
DA 2203-R, 6-20
Four-strand cattle fence, 3-9
Foxholes, 4-2, 4-7
Fuzes, mines, 3-38
Gaps, minefields. 3-21, 3-24
General Purpose Barbed Tape Obstacle (GPBTO), 3-10
Geometric figures, 10-10
Gin pole, 9-8
Guy lines, 9-9
Hand-washing devices, 1-35
Hasty
Bridge classification, 5-6
Fighting positions, 4-9
Nonstandard bridge, 7-68 7-73
Protective minefield, 3-16, 3-19
River crossing, 7-1 - 7-4
Road crater, 6-11
Threat defense, 2-1
Helicopter characteristics, 2-23
Helipad construction and requirements, 2-24 - 2-27
Heliport marking, 2-26
Highline, 9-10
Hitches 9-3
Hositing 9-8
Holdfast, pickets, 9-9
Hooks, 9-2
Individual fighting positions, 4-1
Infantry weapons, 10-21 - 10-23
Injuries. See First aid
Interdiction minefields, 3-16
Iodine tablets, 1-36
Irregular Outer Edge (IOE), 3-24

Job site security, 1-6
Knife rest, 3-11
Knots and lashings, 9-3 - 9-5
Landing mats, 8-10
Landing zones, 2-24, 2-25
Lanes, minefields, 3-21, 3-24
Lashings, 9-3 9-5
Latrines, 1-35
laying unit organization, minefields 3-25
Level
  MOPP, 1-20
  Survivability 4-8
Lifesaving steps, 1-28
Light Tactical Raft (LTR), 7-11, 7-12
Log obstacles
  Abatis, 3-14
  Cribs, 3-12, 3-13
  Hurdles, 3-14
  Post, 3-15
LTR, 7-11, 7-12
M60 Range Card, 4-4
M180, cratering. 6-12
March formulas, 1-3
Markings
  Bridge, 5-19
  Enemy obstacles, 10-29
  Heliports. 2-26
  Lanes, 3-35
  Minefields 3-34
  NBC, 1-24
  Vehicles, 10-19
Material factor for breaching, 6-8
Mechanical advantage, 9-8
Mechanical ambush, 1-9
Medical evacuation (MEDEVAC), 1-32
Medium Girder Bridge (MGB), 7-30 - 7-48
Metal landing mats, 8-10
Military road classification 5-3
Mines
  Expedient, 3-49
  Foreign, AP, 2-9 - 2-12
  Foreign, AT, 2-6 - 2-9
  Scatterable, 3-48
  US, conventional, 3-38
Minefields (NATO standard)
  Authority to lay, 3-17
  Breaching, 2-5
  Clearing, 2-5
  Clusters, 3-21
  Computations, 3-20
  Density, 3-20
  Emplacing, 3-21 - 3-24
  Employment, 3-16
  Gaps/lane, 3-23 - 3-24
  IOE, 3-24
  Lanes, 3-23, 3-24
  Laying unit organzation, 3-25
  Marking, 3-34
  Numbering clusters, 3-23
  Patterns, 3-20, 3-21
  Recording 3-19, 3-28 - 3-33
  Reports, 3-17, 3-18

Minefields (NATO standard) (continued)
Row, 3-20, 3-23
Strips, 3-23
Tripwire, 3-24
Types, 3-16
Minefields (Scatterable) 3-35
Authority, 3-17
Employment, 3-16
Marking, 3-37
Recording, 3-37
Reporting, 3-37
Minefield (Threat)
Breaching, 2-4, 2-5
Characteristics, 2-1
Clearing, 2-4, 2-5
Detecting, 2-3
Recording, 2-3
Reporting, 2-3
Mobility Equipment
Threat, 3-1, 3-2
US, 2-4, 2-13, 2-14, 7-2 - 7-14
Moisture content, 8-4
MOPP levels, 1-20
Movement, order. See Orders
Movements, mounted/dismounted, 1-4
M4T6 Fixed Span w/testle, 7-20 - 7-29
M4T6 fixed Span wo/trestle, 7-20 - 7-25
M4T6 raft, 7-8 - 7-10
Nails and fasteners, 10-5
NBC, 1-15 - 1-27
Agents characteristics, 1-15
Alarms and signals, 1-20
Decontamination, 1-27
Markings, 1-24
MOPP levels, 1-20
Reports, 1-16 - 1-19
Unit degradation, 1-25
Unmasking procedures, 1-24
Warnings, 1-20, 1-21
Oblique triangle, 10-8
Obstacle
Antitank ditch, 3-12
Breaching, 2-13 - 2-17
Demolition, 6-11, 6-12
Expedient, 3-10 - 3-15
Concrete, 3-15
Log, 3-12 - 3-15
Portable, 3-11
Report, 2-13
Steel, 3-15
Standard, 3-26, 3-35, 3-36
Wlre, 3-6 - 3-11
Obstacle breaching/nonexplosive
Equipment, 2-14
Methods, 2-16, 2-17
Procedures, 2-15
Obstacle report, 2-13
Open ditches, 8-9

Operations mounted/dismounted, 1-4
Orders
Movement, 1-1
Operation, 1-2
Warning, 1-1
Organic test, soil, 8-3
Overhead cable, 7-14
Overlay symbols, 5-19 - 5-21, 10-26
Patrolling, 1-6
Phony minefields, 3-16
Picket holdfast, 9-5
Pier demolition, 6-7
Point minefield, 3-16, 3-30
Portable barbed wire obstacles, 3-11
Post obstacle, 3-15
Priming explosives 6-2
Priority of work
Assembly area, 1-4
Bivouac 1-4
Job site 1-6
Protective minefields fields, 3-16
Quartering party, 1-4
Radios
Location, 1-37
Messages, 1-40
Transmission format 1-40
Types 1-37
Raid patrol See Combat patrol
Range Card (M60), 4-4
Rates of marches, 1-3
Rafting equipment, 7-4, 7-8 - 7-10 - 7-11
Reconnaissance
Bridge, 5-7
Bridge demolition, 6-20
Engineer, 5-17
Ford, 5-16
Overlay symbols, 5-19
Patrol, 1-6
Reports, 5-2
Road, 5-3
Route, 5-1
Tunnel, 5-14
Water, 5-15
Recording, minefields
Enemy, 2-3
Ford mining, 3-33
Hasty protective, 3-19
Point minefields, 3-30, 3-31
Scatterable minefields, 3-37
Standard pattern minefields, 3-28 - 3-29
Recovery vehicle, 9-11
Repair
Airfield, 8-11
Road, 2-23
Relative effectiveness tactor, 6-2
Relieved faced crater, 6-11
Removal, mines, 2-6
Reports
Demolition reconnaissance, 6-20
Enemy minefield, 2-3
Enemy obstacles, 2-13
Minefields, 3-16

Reports (continued)
NBC, 1-16
Obstacles, 2-13
Reconnaissance, 5-2
Road reconnaissance, 5-3
Route, 5-2
SALUTE report, 1-6
Revetments, type, 4-13
Ribbon bridge/raft, 7-5 - 7-7
Ribbon charge, 6-5
Ribbon test soil, 8-3
Rigging
Blocks, 9-8
Boom derrick, 9-7
Chains, 9-2
Deadman, 7-14
Fastenings, 9-5
Gin pole, 9-8
Guy lines, 9-9
Holdfast, 9-9
Hooks, 9-2
Knots and lashings, 9-3 - 9-5
Ropes, 9-1, 9-2
Shears, 9-7
Slings, 9-6
Splices, 9-4
Right triangles, 10-10
Ring charge, 6-6
River crossing
Equipment, 7-2 - 7-5, 7-8 - 7-10
Operation, 7-1
River reconnaissance, 5-15
Road classification formula, 5-3
Road construction hasty, 2-18
Cross section, 2-18
Design, 2-18
Drainage, 8-4
Soils, 8-1 - 8-3
Road marches, 1-1
Road reconnaissance, 5-3
Road surfaces, expedient, 2-18
Ropes, 9-1, 9-2
Rope clips, 9-5
Rope splices, 9-4
Route
Classification formula, 5-1
Reconnaissance, 5-1
Sweep, 2-6
Row mining, 3-20
Runoff, 8-4
Saddle charge, 6-5
Safety, explosives, and demolitions, 6-1
SALUTE, 1-6
Sand grids, 2-22
Sandbag revetment 4-13
Sanitation facilities
Hand washing, 1-35
Latrines, 1-35
Showers, 1-35
Scatterable
Minefields, 3-35
Mines, 3-48

Screen, camouflage, 4-19
Screws, 10-5
Security
  Communication 1-40
  Job site, 1-6
  Patrol, 1-7
  Road march, 1-1 - 1-3
Sedimentation test, soil, 8-3
Shaking test, soils, 8-3
Shears, 9-7
Shelters, 4-17
Shine test, soil, 8-3
Shore guys, 7-13
Shower unit, 1-35
Signals
  NBC, 1-20
  Visual, 1-41
Signs
  Bridges, 5-19
  Minefield marking, 3-34
  NBC marking, 1-24
  Threat NBC marking, 1-24
  Vehicle classification 10-19, 10-20
Slings 9-6
Slope measurements, 5-1, 5-2
Smoke, artillery, 1-13
Soils
  Characteristics, 8-1
  Identification tests, 8-2
  Stabilization, 8-4
Sommerfeld track, 2-21
Specific gravities, 10-1
Spikes, 10-6
Splices, rope, 9-3
Spruce timbers, for gin pole, 9-3
Standard Obstacles, 3-26, 3-35, 3-36
Standard pattern minefield, 3-29
Steel cutting charges, 6-4, 6-5
Sting and bites first aid, 1-30
Stream velocity, 5-16
Stream width, 5-16
Strip centerline, 3-22, 3-23
Stumping, 6-7
Survivability
  Individual/Crew position, 4-1
  Levels, 4-8
  Positions versus Antitank ditch, 3-4
  Shelters, 4-13
  Vehicle positions, 4-9
Symbols
  Engineer resources, 5-21
  Overlay, 5-19
  Unit, 10-26
  Weapons, 10-27, 10-28
Tackle systems, 9-8
Tactical minefield, 3-16
Tactical road marches, 1-1
Tamping factor, 6-9
Tanglefoot, 3-10
Tetrahedron, 3-15
Thread test, soil, 8-3
Timber, cutting, 6-6

Timber, spruce 9-3
Timber trestle bridge, 7-68 - 7-73
Time distance conversion, 10-18
Threat
  Deliberate defense, 2-1, 2-2
  Engineer equipment, 2-3
  Equipment, 3-1
  Hasty defense, 2-1
  Minefield report, 2-3
  Mines. See foreign mines
  NBC markings, 1-24
  Obstacle breaching equipment, 3-2
  Obstacle reporting, 2-13
  Offense, 3-1
Tower, anchorage system, 7-13 - 7-20
Trails. See Road construction
Tread roads, 2-20
Tree blasting, 6-7
Trestle apron fence, 3-11
Tren hes, 4-13
Trogonometric function, 10-7
Trip flares, 3-45
Tripwires, 3-24
Triple standard concertina, 3-8
Troop leading procedures, 1-4
Troop movement factors, 1-3
Tunnel reconnaissance, 5-14
Unit identification symbols, 10-27, 10-28
Unmasking procedures, 1-24
Vehicle classification, 10-19, 10-20
Vehicle fighting position, 4-9 - 4-12
Vehicle markings, 10-20
Vehicle recovery, expedient, 9-11
Visual signals
  Flashlight, 1-43
  Hand and arms, 1-41
Volumes of geometric figures, 10-10
Wall destruction, 2-16
Wall Retaining, 4-14
Warning order, 1-1
Warnings (NBC), 1-20, 1-21
Washing facilities, 1-35
Waste disposal, 1-35
Water
  Disintectation, 1-36
  Quantity requirement, 1-36
  Reconnaissance, 5-15
Weapons fighting position, 4-1
Weapons symbols, 10-27, 10-28
Weapons, threat, 3-1
Weapons US, 10-19 - 10-25
Weigh and specific gravities, 10-1 - 10-2
Wire mesh roads, 2-22
Wire obstacles
  Cattle fences, 3-9
  Double apron fences, 3-7
  Logistical requirements, 3-5
  Portable obstacles, 3-11
  Road blocks, 3-11
  Triple standard concertina, 3-8
Wire rope, 9-1
Wire rope clips, 9-5

Work priority, 1-4
Assembly area, 1-4
Bivouac area, 1-4
Job site, 1-6
Wounds. See First aid

# REFERENCES

## REQUIRED PUBLICATIONS

Required publications are sources that users must read in order to understand or comply with FM 5-34.

### Department of the Army Form (DA Form)

| | |
|---|---|
| **1248** | Road Reconnaissance Report |
| **1249** | Bridge Reconnaissance Report |
| **1250** | Tunnel Reconnaissance Report |
| **1251** | Ford Reconnaissance Report |
| **1252** | Ferry Reconnaissance Report |
| **1355** | Minefield Record |
| **1355-1-R** | Hasty Protective Minefield Record |
| **1711-R** | Engineer Reconnaissance Report (LRA) |
| **2203-R** | Demolition Reconnaissance Report |

### Field Manual (FM)

| | |
|---|---|
| **5-25** | Explosives and Demolitions |
| **5-36** | Route Reconnaissance and Classification |
| **5-100** | Engineer Combat Operations |
| **5-101** | Mobility |
| **5-102** | Counter mobility |
| **5-103** | Survivability |
| **5-104** | General Engineering |
| **5-106** | Employment of Atomic Demolition Munitions |
| **5-134** | Pile Construction |
| **5-164** | Tactical Land Clearing |
| **5-165** | Hasty Revetments for Parked Aircraft |
| **5-166** | Well Drilling Operations |
| **5-233** | Construction Surveying |
| **5-277** | Bailey Bridge |
| **5-335** | Drainage |
| **5-541** | Military Soils Engineering |
| **5-742** | Concrete and Masonry |
| **6-20** | Fire Support in Combined Arms Operations |
| **20-31** | Electric Power Generation in the Field |
| **20-32** | Mine/Counternline Operations |
| **21-10** | Field Hygiene and Sanitation |
| **90-13(HTF)** | River Crossing Operations (How to Fight) |
| **101-10-1** | Staff Officers' Field Manual Organizational Technical and Logistical |

### Graphic Training Aid (GTA)

| | |
|---|---|
| **5-2-12** | Protractor |

### Technical Manuals (TM)

| | |
|---|---|
| **5-200** | Camouflage Materials |
| **5-210** | Military Floating Bridge Equipment |
| **5-232** | Elements of Surveying |
| **5-312** | Military Fixed Bridges |
| **5-315** | Firefighting and Rescue Operations in Theaters of Operations |
| **5-330** | Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations |
| **5-331A-E** | Utilization of Engineer Construction Equipment |
| **5-332** | Pits and Quarries |
| **5-333** | Construction Management |
| **5-337** | Paving and Surfaciing Operation |
| **5-342** | Logging and Sawmill Operation |
| **5-461** | Engineer Handtools |
| **5-624** | Maintenance and Repair of Surface Areas |
| **5-725** | Rigging |
| **5-5420-209-12** | Operator's and Organizational Maintenance Manual for Improved Float Bridge (Ribbon Bridge) |
| **5-5420-212-12** | Operator's and Organizational Maintenance Manual for Medium Girder Bridge (MGB) |
| **5-5420-212-12-1** | Operator's and Organizational Maintenance Manual Link Reinforcement Set for Medium Girder Bridge |
| **5-6665-202-13** | Operator's Organizational and Direct Support Maintenance Manual for Detecting Sets, Mine |

**Technical Manuals-continued**

| | |
|---|---|
| **9-1300-214** | Military Explosives |
| **9-1375-213-12** | Operator's and Organizational Maintenance Manual (including repair parts and special tools list) for Demolition Materials |

## RELATED PUBLICATIONS

Related publications are sources of additional information. They are not required in order to understand FM 5-34.

### NATO Standardization Agreements (STANAGs)

| | |
|---|---|
| **2002** | Warning Signs for the Marking of Contaminated or Dangerous Land Areas, Complete Equipment, Supplies and Stores |
| **2010** | Military Load Classification Markings |
| **2017** | Orders to the Demolition Guard Commander and Demolition Firing Party, Commander (Non-nuclear) |
| **2019** | Military Symbols for Land Based Systems |
| **2021** | Computation of Bridge, Raft and Vehicle Classification |
| **2027** | Marking of Military Vehicles |
| **2036** | Land Minefield Laying, Recording, Reporting and Marking Procedures |
| **2096** | Reporting Engineer Information in the Field |
| **2123** | Obstacle Folder |
| **2136** | Minimum Standards of Water Potability |
| **2269** | Engineer Resources |
| **2885** | Procedures for the Treatment, Acceptability and Provision of Potable Water in the Field |
| **2889** | Marking of Hazardous Areas and Routes Through Them |
| **2989** | Transfer of Barriers |
| **2990** | Principles and Procedures for the Employment in Land Warfare of Scatterable Mines with a Limited Laid Life |
| **2991** | NATO Glossary of Engineer Terms and Definitions |

DEPARTMENT OF THE ARMY
UNITED STATES ARMY ENGINEER SCHOOL
FORT BELVOIR VIRGINIA 22060

REPLY TO ATTENTION OF

June 8, 1987

ATZA-CG

Engineer Soldiers and Leaders,

Engineers on today's battlefield have a more demanding job than most. Engineers have to be physically and mentally tough. When called by their maneuver or engineer commander, they have to provide quick, accurate engineer solutions to warfighting missions.

This handbook provides a single pocket-reference for you to do that job and do it well! I am confident that skilled engineers will be able to use this handbook to meet any battlefield challenge!

R. S. KEM
Major General, USA
Commandant

Center for Excellence

Field Manual No. 5-34

*FM 5-34

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 14 September 1987

# ENGINEER FIELD DATA

Users require a ruler and a protractor (GTA 5-2-12) to supplement this document.

The proponent of this publication is the US Army Engineer School. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) to— Commandant, US Army Engineer School, ATTN: ATZA-TD-P, Ft. Belvoir, VA 22060-5291.

The provisions of this publication are the subject of the following International Standardization Agreements (STANAG), 2010, Military Load Classification Markings; 2021, Computation of Bridge, Raft and Vehicle Classifications; 2036, Land Minefield Laying, Recording, Reporting and Marking Procedures, 2096, Reporting Engineer Information in the Field; 2123, Obstacle Folder; 2889, Marking of Hazardous Areas and Routes Through Them; 2990, Principles and Procedures for the Employment in Land Warfare of Scatterable Mines with a Limited Laid Life; and 2991, NATO Glossary of Engineer Terms and Definitions.

Unless otherwise stated, whenever the masculine gender is used, both men and women are included.

DISTRIBUTION RESTRICTION: Approved for public release; distribution is unlimited.

*This publication supersedes FM 5-34, 24 September 1976.